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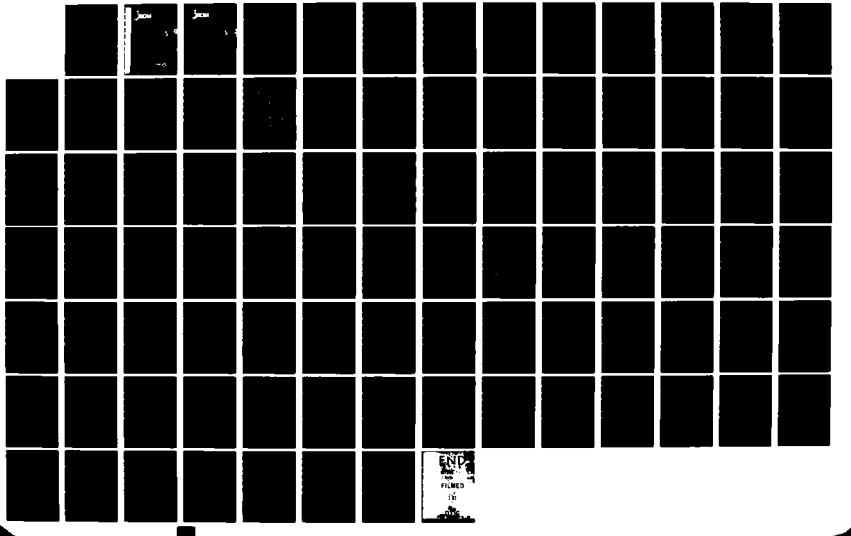

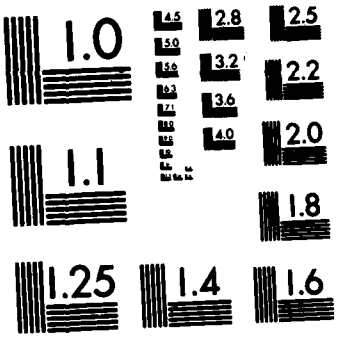

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NUCLEAR OPERATIONS AND DECISIONMAKING IN THE INTEGRATED NUCLEAR AND CONVENTIONAL THEATER WARFARE SIMULATION (INWARS) (DRAFT)

THE BDM CORPORATION

7915 Jones Branch Drive
McLean, Virginia 22102
Phone (703) 821-5000

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NUCLEAR OPERATIONS AND DECISIONMAKING IN THE INTEGRATED NUCLEAR AND CONVENTIONAL THEATER WARFARE SIMULATION (INWARS) (DRAFT)

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FOREWORD

This draft document presents the treatment of nuclear operations and decisionmaking in the Integrated Nuclear and Conventional Theater Warfare Simulation (INWARS) under development for the U.S. Army by The BDM Corporation. The document may be regarded as an extension of the (DRAFT) LEVEL III SPECIFICATIONS FOR INWARS (BDM/W-78-402-TR, 24 July 1978, 5 volumes).

The design of the representations presented below has benefited greatly from a series of informal working groups held by the Army in late 1978.

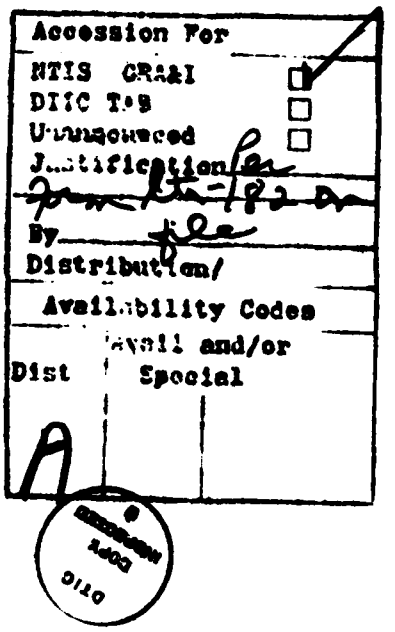


TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

TABLE OF CONTENTS (CONTINUED)

LIST OF FIGURES

LIST OF FIGURES (CONTINUED)

CHAPTER I
INTRODUCTION

A. INTRODUCTION

This paper presents the treatment of nuclear weapons employment and its impacts on various types of force elements in INWARS. This introductory chapter surveys the role of nuclear operations in INWARS and provides an overview of the nuclear employment process in INWARS, both in terms of the decisions leading to nuclear employment and the impact of nuclear employments upon force element capabilities and operations.

B. BACKGROUND

The employment of nuclear weapons and the operational changes resulting from such an employment are a principal focus in the INWARS development. Recalling the objectives of the INWARS program:

"F.1.1 Evaluating military and political constraints on conventional, chemical, and nuclear operations;

"F.1.2 Identifying interactions among conventional, chemical, and nuclear operations;

"F.1.3 Measuring impact on conventional war of the threatened use of nuclear weapons;

"F.1.4 Evaluating significant decision options at theater, army group, and corps levels, and

"F.1.5 Developing typical combat situations within which corps and division level models can be applied for more detailed analyses." (from INWARS Statement of Work (SOW), paragraph F.1.)

The significance of nuclear operations is apparent, being explicitly referenced in the first three objectives and clearly implicit in the last two objectives. Decision processes relating to nuclear employment must be

simulated to some extent to achieve these objectives. The following points under the SOW description of Task 1, Simulation Development, are pertinent:

> "F.3.1.1. Explicit representation of the theater force command structure for both sides from division level to theater level, with decision processes to determine allocation of resources, employment of forces, and missions for each headquarters above division level. The decision processes shall deal with integrated conventional, nuclear, and chemical operations in theater warfare. Major considerations shall be included regarding transition between levels of warfare and implementation of national strategies and doctrines. (emphasis added).
>
> "F.3.1.3. Conventional combat simulation shall include non-nuclear combat under the threat of nuclear weapons and in a post-nuclear strike environment, particularly representing adaptive measures to be taken relative to the nuclear and chemical risk. (emphasis added)
>
> "F.3.1.5. Distinction among nationalities in decision options, nuclear and chemical targeting, and logistics. (emphasis added)
>
> "F.3.1.6. Reflection of major asymmetries on opposing sides in force organizations, deployments, replacement doctrines, and weapon and unit employment doctrines, particularly in regard to nuclear and chemical weapons." (emphasis added)

These SOW specifications illustrate the breadth of features related to nuclear operations which must be treated in INWARS. It is important to note that while the employment decisions themselves are important, so too are the pre-employment decisions by which each side perceives and adapts its ongoing operations to the nuclear threat posed by the opposing side, and the post-employment decisions by which each side perceives the impact of the employment and determines how to exploit or respond to it. It is in this sense that INWARS reflects the "integrated" nature of theater nuclear warfare.

It is emphasized that these various aspects of nuclear operations are represented in a highly simplified and aggregated fashion in INWARS. The actual planning and decisionmaking in this area is obviously very complex, and there has been no attempt to directly represent its structure and content in INWARS. Simplifications have been necessary to develop a

representation which will not require inordinate computer storage and run time. It is felt, however, that the representation described below offers the user considerable flexibility and control, while still reflecting principal features and influences in the area of nuclear operations as described in the relevant Army field manuals (FM 6-20, FIRE SUPPORT IN COMBINED ARMS OPERATIONS, September 1977, Chapter 6; FM 21-40, NBC DEFENSE, October 1977; and FM 101-31-1, NUCLEAR WEAPONS EMPLOYMENT DOCTRINE AND PROCEDURES, March 1977).

C. SURVEY OF NUCLEAR OPERATIONS AND IMPACTS IN INWARS

This subsection presents a broad overview of the INWARS treatment of nuclear operations. The purpose is to provide an orienting framework around which to structure the detailed presentations in later chapters.

1. Impact of the Nuclear Threat in INWARS

The possibility of nuclear employment in INWARS may vary over the course of a particular run as battlefield conditions change. To some extent, these varying possibilities will be perceivable by the simulated C^2I elements. For example, to the extent that Blue is holding solidly in position, he may infer an increasing risk of nuclear attack by Red. This exhibits an indirect "inferential" perception of nuclear threat. C^2I elements may also perceive the nuclear threat more directly if they "observe" opposing forces preparing for a nuclear attack. Indirect and direct indicators of nuclear threat are integrated ("fused") by INWARS C^2I elements in the form of a "Nuclear Threat Index." This index is computed by a simple Bayesian updating system applied to various relevant conditions and information elements.

The nuclear threat indices impact on the operations of C^2I elements in two basic ways. First, the level of the threat index may (at user discretion) be considered in developing operations; specifically, the suitability of a concept of operation may take account of nuclear threat level. Second, "operationally significant" changes in the nuclear threat index may trigger: (1) implementation or de-implementation of certain

"adaptive measures" intended to reduce the impact of a nuclear attack, and/or (2) consideration of various alterations to ongoing operations ranging from minor adjustments to complete redevelopment.

Redevelopment of operations is also the response to the employment of nuclear weapons by the enemy -- the realization of the nuclear threat. When actually attacked with nuclear weapons, INWARS C^2I elements will implement appropriate adaptive measures, notify their parent C^2I elements of the attack, and immediately begin a redevelopment of operations.

2. Nuclear Employment in INWARS

At some point in the course of a particular simulation run, one (or more) of the simulated C^2I elements may decide to employ nuclear weapons. This section discusses the form in which nuclear weapons are employed in INWARS, the process (or "cycle") of employment, and the form of the considerations involved throughout the employment cycle.

a. Form of Employment

In INWARS, nuclear weapons are employed in the form of packages somewhat analogous to actual packages of nuclear weapons. INWARS C^2I elements design, decide, and interact in terms of nuclear packages; likewise, INWARS nuclear implementors carry out directives concerning the provision or delivery of certain packages.

b. The Employment "Cycle"

The process by which nuclear employment is considered, planned, and executed in INWARS involves interations among the individual employment decisions of several C^2I elements. Indeed, many of these decision processes are triggered by the result of other C^2I elements' decision processes. Though somewhat artificial, it is convenient to partition these interactions into four basic stages: (1) initiation stage; (2) request stage(s); (3) authorization stage; and (4) implementation stages.

1) Initiation Stage

In considering the situation it faces, some INWARS C^2I element may recognize an operational problem or opportunity for which

nuclear weapons employment is a "sound response" (relative to its user-supplied operating doctrine). This will cause that C^2I element to consider nuclear weapons employment. The consideration process may result in a decision to employ a certain specific package of nuclear weapons. Recognition of an operational problem or opportunity is thus the basic necessary (though not sufficient) condition for initiation.

2) Request Stage(s)

Generally, the C^2I element which desires to employ nuclear weapons will not have the power to authorize their use. Hence, he must request employment authority from his superior C^2I element. Such a request is made (via communications) for the specific package he wishes to use. Receipt of a nuclear request stimulates the superior C^2I element to consider the use of nuclear weapons. The consideration process by the superior is similar to that of the subordinate, and may result in a decision to employ a certain specific package of nuclear weapons. Unless the superior has the power to authorize nuclear use, it must then request authorization from its superior.

Thus, the request stage consists of a sequence of requests rising up the chain of command until a level is reached which has the power to authorize the employment of nuclear weapons. Before discussing the authorization decision, it is worth noting that the specific package requested may grow, shrink, or otherwise change as the process proceeds up the chain of command. In particular, the package may shrink to nothing, which stops the process. In such a case, the subordinate is notified.

3) Authorization Stage

Eventually a request may reach a C^2I element at a level of command which has the power to authorize the employment of nuclear weapons. Such an element goes through a process of considering nuclear employment which is similar to that already carried out by his subordinates. The requested package may be completely denied or modified during this process. If a non-null package is authorized, the subordinate is notified accordingly.

4) Implementation Stage

Once a package is authorized, it must be passed back down the chain of command for implementation, perhaps at several levels. The receipt of an authorization again stimulates the consideration of nuclear employment. However, the consideration process is now constrained to use the specific weapons authorized. The resulting package specification forms the basis for authorizations to the next lower level. Any provision of nuclear munitions from this echelon to the next echelon is implemented by nuclear provision directives. Any actual deliveries from immediately subordinate delivery entities are implemented by delivery directives.

c. Form of Nuclear Considerations

The consideration process utilized by C^2I elements throughout the employment cycle is represented as a concept-directed activity in INWARS. Like operations development, the design of nuclear packages is guided by certain user-specified concepts which describe, in an abstract form, the basic alternative ways to employ nuclear weapons. Thus, concepts of nuclear employment in INWARS concern such things as target priorities and desired levels of effect. Through an interlaced series of specification and assessment steps, available concepts of nuclear employment are refined into specific nuclear packages. Concepts which are inappropriate are "weeded out" as soon as they fail the assessment criteria at some stage of refinement. It is important to note that unlike operations development, nuclear package design need not produce any package. In other words, there is no nuclear employment concept of "last resort": if none of the concepts can be transformed into an acceptable package, nuclear weapons will simply not be employed.

As an afterword to this survey, it might be noted that a similar set of processes will be utilized to represent chemical weapons employment in INWARS -- i.e., the same types of considerations, although with different decision criteria and thresholds.

D. OVERVIEW OF PRESENTATION

The discussion of how these various decisions and impacts are represented in INWARS begins in Chapter II with a survey of the INWARS Tactical Nuclear Force (TNF) and the forms in which different TNF elements interact. Chapter III covers operations under the nuclear threat, including the perception of the threat, responses to it, and reaction to its realization in the form of a nuclear attack. Chapters IV and V then present the nuclear employment decision process. Their basic structure is surveyed in Chapter IV; the detailed decisions -- "employment design procedures" -- are presented in Chapter V. Finally, Chapter VI presents the processes by which authorized nuclear employments are executed and surveys their effects.

CHAPTER II
REPRESENTATION OF THE TACTICAL NUCLEAR FORCE (TNF) IN INWARS

A. INTRODUCTION

The nuclear threat may ultimately impact on any of the force elements represented in INWARS. However, a more limited group of force elements are actively involved in the actual employment of nuclear weapons. This group of force elements may be considered to be the INWARS representation of the Tactical Nuclear Force. The structure of this group of force elements will be discussed and their modes of interaction will be surveyed in Sections B and C, below.

B. STATIC STRUCTURE OF INWARS TNF

The INWARS TNF is portrayed graphically in Figure II-1. This structure is conveniently discussed in terms of TNF decisionmakers and TNF implementors.

1. TNF Decisionmakers in INWARS

Decisions relating to the employment of tactical nuclear weapons in INWARS will be made by air and ground C^2I elements at echelons above division. The nuclear employment process generally involves decisions at several of these echelons. The nature of these decisions themselves will be discussed in more detail in Chapters IV and V.

2. TNF Implementors in INWARS

At its most primitive level, implementing a decision to employ nuclear weapons involves delivering designated nuclear munitions against a designated target (or targets). In INWARS, three distinct types of entities can deliver nuclear munitions: (i) nuclear-capable artillery units, (ii) nuclear-capable surface-to-surface missile (SSM) pools, and (iii) nuclear-capable air mission packages. The modifier 'nuclear-capable' emphasizes that all artillery units need not be capable of delivering

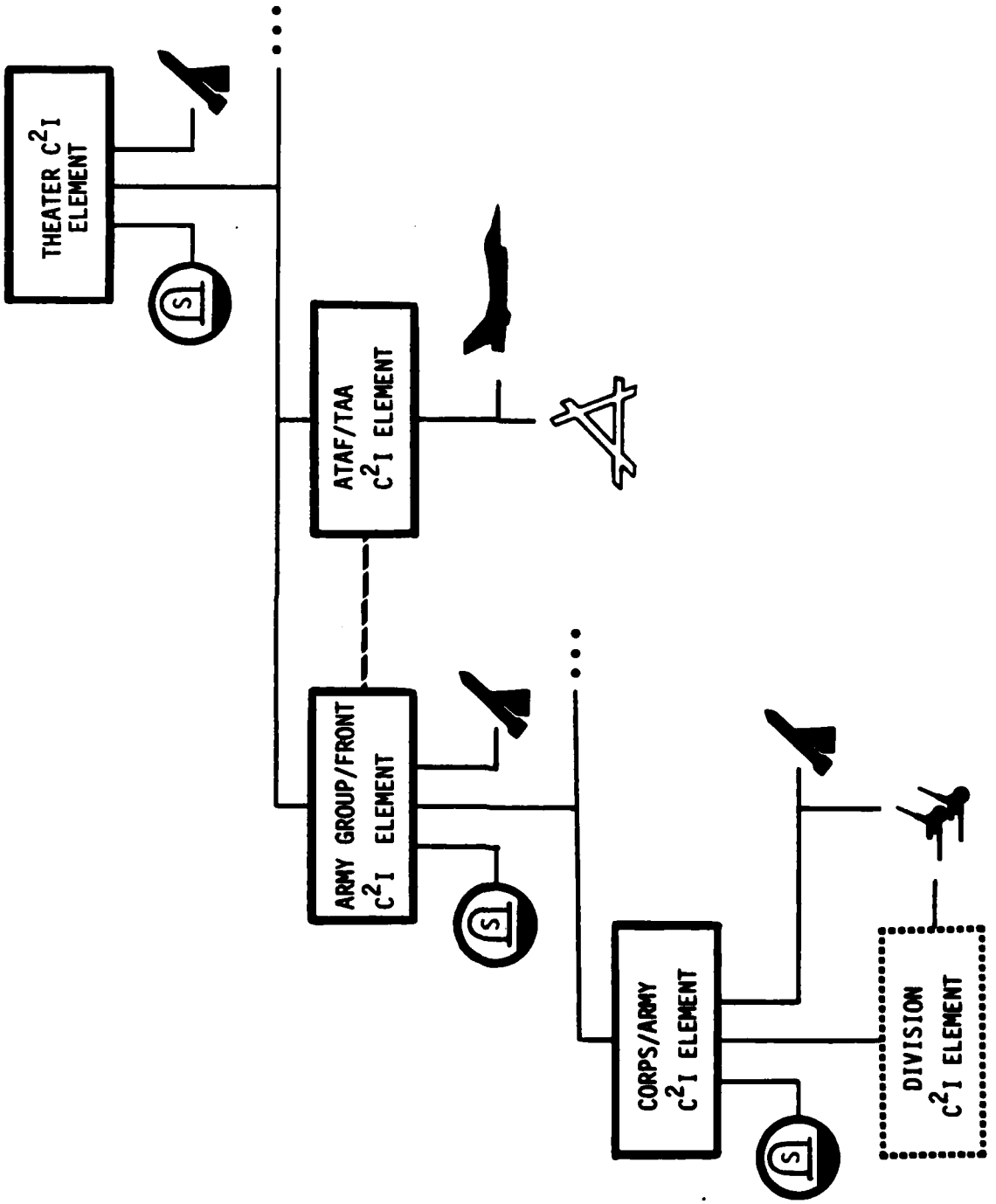


Figure II-1. INWARS TNF Structure

nuclear munitions in INWARS; rather, certain artillery units may be designated as nuclear capable. However, delivery capability is not sufficient for implementation: nuclear weapons must also be available for delivery. In INWARS, nuclear weapons are stored at nuclear supply points which, upon command, will provide appropriate weapons to the delivery entities. Thus, implementation of a nuclear weapons employment decision involves: (1) issuing provision directives to nuclear supply points in order to provide weapons as required to delivery entities, and (2) issuing delivery directives to the delivery entities.

C. TNF ELEMENT INTERACTIONS IN INWARS

The process of employing nuclear weapons in INWARS will generally involve interactions among several types of force elements at several echelons. As with all but the lowest level interactions in INWARS, these interactions will be carried out via communications. The interactions themselves can therefore be characterized in terms of the associated message structures. Interactions among TNF elements relating to nuclear employment involve four distinct message types: (1) nuclear employment requests, (2) nuclear employment authorizations, (3) nuclear provision directives, and (4) nuclear delivery directives. One additional message type -- nuclear warning notices -- provides for interactions of the TNF with non-TNF elements. These messages and their overall flows are portrayed in Figure II-2.

1. Nuclear Employment Requests

Nuclear employment requests are formulated by lower level C^2I elements without the authority to employ nuclear weapons. Once formulated, such messages are transmitted by the requesting C^2I element to its immediate superior. This stimulates the superior to consider the nuclear employment and approve, modify, or deny the request. If the superior does not have authority to employ nuclear weapons, he implements his approval or modification by formulating an appropriate nuclear employment request for transmission to his superior. However, if the superior does have the

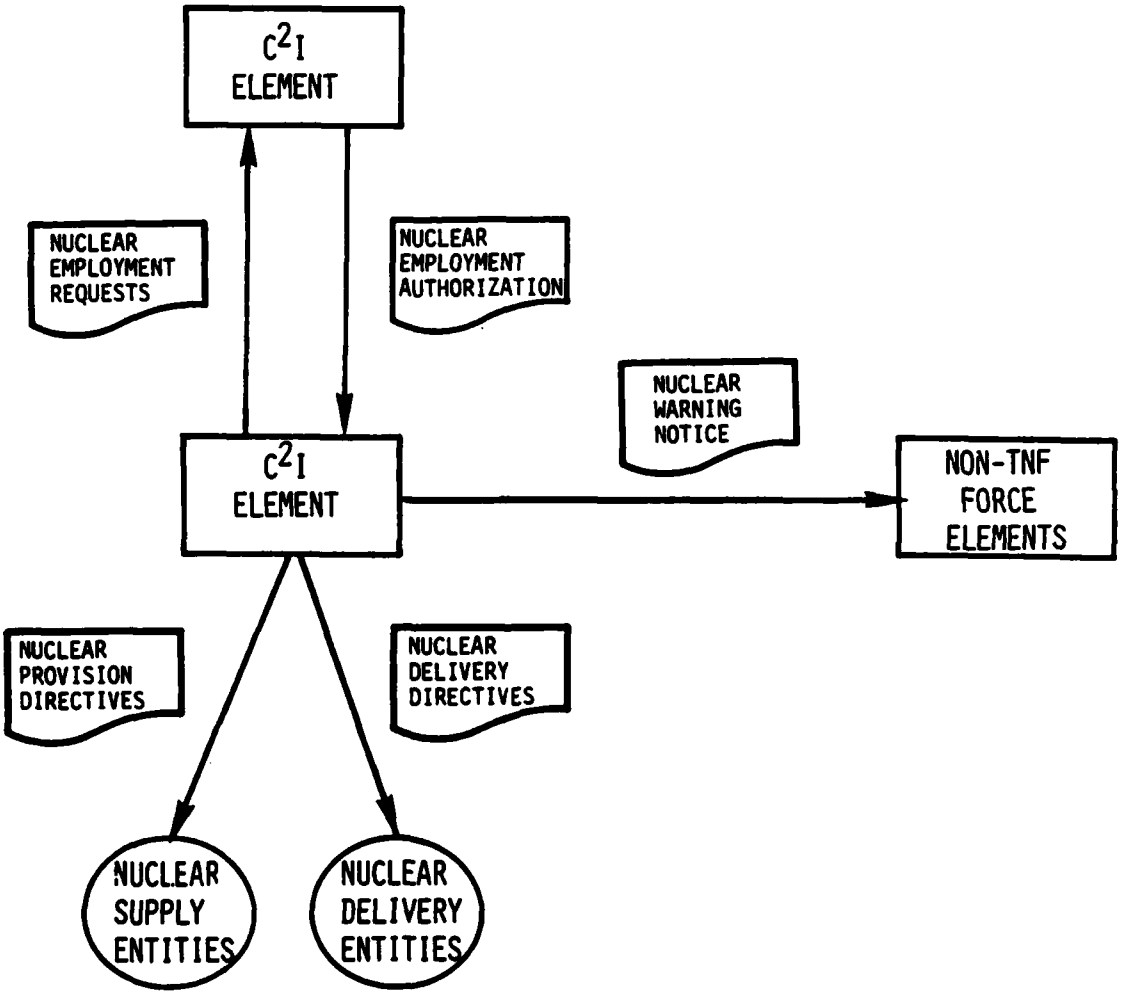


Figure II-2. TNF Interactions Message Types and Flows

employment authority, he implements an approval or modification by formulating an appropriate authorization for transmission to the requestor.

2. Nuclear Employment Authorizations

As just indicated, nuclear employment authorizations are formulated by higher level C^2I elements having the authority to employ nuclear weapons. They are typically formulated in response to employment requests from lower level C^2I elements; however, the authorized employment may differ from the requested employment. Once formulated, the authorization is transmitted to the requestor (and, perhaps, certain other C^2I elements). The receipt of an authorization stimulates a C^2I element to consider nuclear employment within the limits set by the authorization. If the recipient C^2I element does not directly control any TNF implementors, he implements the authorization by authorizing some or all of his subordinates to employ nuclear weapons. If, however, implementing capabilities are directly controlled, the implementation of the authorization may additionally involve provision and/or delivery directives.

3. Nuclear Munition Provision and Delivery Directives

Nuclear provision and delivery directives provide the means by which C^2I elements cause nuclear weapons to be employed. These directives go, respectively, to nuclear supply point and nuclear delivery entities (missile, air, or artillery). Both types of directives specify the transfer of a certain amount of nuclear weapons from the implementing entity to some other entity. The basic difference is that under a provision directive, the weapons are transferred to a friendly force element for further distribution or delivery, whereas under a delivery directive, the weapons are transferred to a temporary entity ("nuclear effects entity") which inflicts their effects on appropriate force elements and terrain.

4. Nuclear Employment Warnings

Nuclear employment warnings are formulated by C^2I elements as a part of implementing an authorization for nuclear employment. Once formulated, the warnings are sent to friendly force elements so that they may prepare for the impending employment. This may include implementing adaptative measures as well as adjusting or redeveloping operations.

CHAPTER III
OPERATING UNDER THE THREAT OF NUCLEAR WEAPONS EMPLOYMENT

A. INTRODUCTION

Because of the massive effects of nuclear weapons, force elements may operate differently under different levels of nuclear threat. Such differences in operations may well influence the course of the conflict. Moreover, as the nuclear threat increases, force elements may undertake special actions to reduce their vulnerability to a nuclear attack, or to mitigate the effects of the weapons if an attack occurs. Such actions -- so-called "adaptive measures" -- will typically bear a cost in the form of reduced operational effectiveness or efficiency. These and other processes by which forces adapt their operations to the nuclear threat constitute an important dimension of integrated warfare. This chapter presents the treatment of those processes in INWARS. Section B concerns the processes by which the nuclear threat is perceived by C^2I elements. Sections C and D discuss the impact of this threat perception on the development and execution of operations. Finally, Section E discusses the response of C^2I elements when attacked with nuclear weapons.

B. PERCEIVING THE NUCLEAR THREAT

As indicated in Chapter I, above, INWARS C^2I elements perceive the nuclear threat in the form of a Nuclear Threat Index. Each C^2I element maintains its own Nuclear Threat Index as a part of its Understanding of the Situation (UOS). These indices summarize or "fuse" information about a variety of battlefield events and conditions into a single ordinal indication of the level or degree of nuclear threat. Section B.1 catalogs the types of events and conditions in INWARS which may be relevant to nuclear threat. Section B.2 provides a discussion of how the Nuclear Threat Index represents the threat level. Finally, Section B.3 presents the method for updating the index in response to new information.

1. Information Relevant to the Level of Nuclear Threat

Various types of information received or developed by a C^2I element may be relevant to the threat of nuclear weapons employment by its enemy. Most directly relevant is information concerning actions or activities undertaken by the enemy which the C^2I element believes to be preparatory or prerequisite to enemy employment of nuclear weapons. Also relevant is information concerning conflict conditions which the C^2I element believes may favor nuclear weapons employment under the assumed enemy nuclear doctrines. Finally, friendly actions may be relevant to the extent that they may be perceived by the enemy as provocations.

a. Indicating Activity Information

As suggested in the introduction, actions and activities involved in employing nuclear weapons may include:

(1) A series of employment requests flowing up through the chain-of-command to an authorization point.

(2) An authorization decision followed by a series of implementing authorizations and directives flowing down through the chain-of-command to implementors.

(3) Composition and transportation (as required) of nuclear munitions among nuclear supply points and delivery entities.

(4) Preparation by delivery entities (as required) to execute the specified deliveries.

(5) Warning and preparation of other force elements (as required) to withstand and then exploit the nuclear employment.

(6) Delivery of munitions as directed.

(7) Impact of the munitions on the target with resulting effects.

All of these actions and activities are indicators of impending nuclear employment. Thus, if a particular C^2I element receives information that opposing force elements have undertaken one or more of these activities, it may presume an increasing nuclear threat. Such information may come from the various sources portrayed in Figure III-1.

Enemy Activity \ Information Source			Superior C^2 Element	Subordinates			
				C^2 Element (If Any)	Force Element (If Any)	SIGINT Agency	PHOTINT Agency
Communications	Employment Request		•	•		•	
	Employment Authorization		•	•		•	
	Package Supply/Issue Directive		•	•		•	
	Package Delivery Directive		•	•		•	
	Warning/Preparation Directive		•	•		•	
Physical Actions/Activities	Composition, Issue, Transportation & Receipt of Nuclear Munitions		•	•			•
	Preparation to Deliver Munitions		•	•			•
	Adaptive Measures	Increasing Nuclear Readiness State	•	•	•		•
		Protect/Preserve Delivery Capabilities	•	•			•
	Delivery of Nuclear Munitions		•	•	•		•
	Impact of Nuclear Munitions on Target		•	•	•		•

Figure III-1. Indicating Activity Types and Sources

b. Indicating Condition Information

Indicating activity information concerns overt enemy behavior potentially associated with nuclear weapons employment. The decision processes which initiate and sustain such behavior cannot be directly observed. In a sense, indicating activities are the observable consequences of such decision processes (and may therefore be interpreted as signifying the occurrence of the corresponding decisions). The battlefield situations and conditions which lead to the decisions provide another form of indication: If a C^2I element makes certain assumptions about the conditions under which opposing forces will consider nuclear employment, then whenever such conditions occur, that C^2I element may presume -- perhaps incorrectly -- an increasing nuclear threat. The types of indicating conditions to be treated in INWARS are shown in Figure III-2.

c. Provocation Information

Certain actions taken by a C^2I element may tend to provoke opposing forces to employ nuclear weapons. The mechanism of provocation in INWARS is an increase in the nuclear threat perceptions of the opposing side: This increase may increase the "propensity" to employ nuclear weapons, or even trigger preemptive or retaliatory employment. Only rather blatant provocation information will be treated in INWARS as shown in Figure III-3; the full subtlety of provocation and counter-provocation is outside the scope of INWARS.

2. The Nuclear Threat Index

The nuclear threat perception of a particular C^2I element reflects a synthesis of all information available to that element which concerns indicating activities and conditions, and provocation. This composite perception is represented in INWARS in the form of a Nuclear Threat Index (NTI) maintained by each C^2I element as a part of its Understanding of the Situation (UOS). The index is a non-negative number whose magnitude indicates the relative level of nuclear threat perceived by a C^2I element.

To interpret the Nuclear Threat Index, note that "nuclear threat" concerns the potential employment of nuclear weapons by opposing force

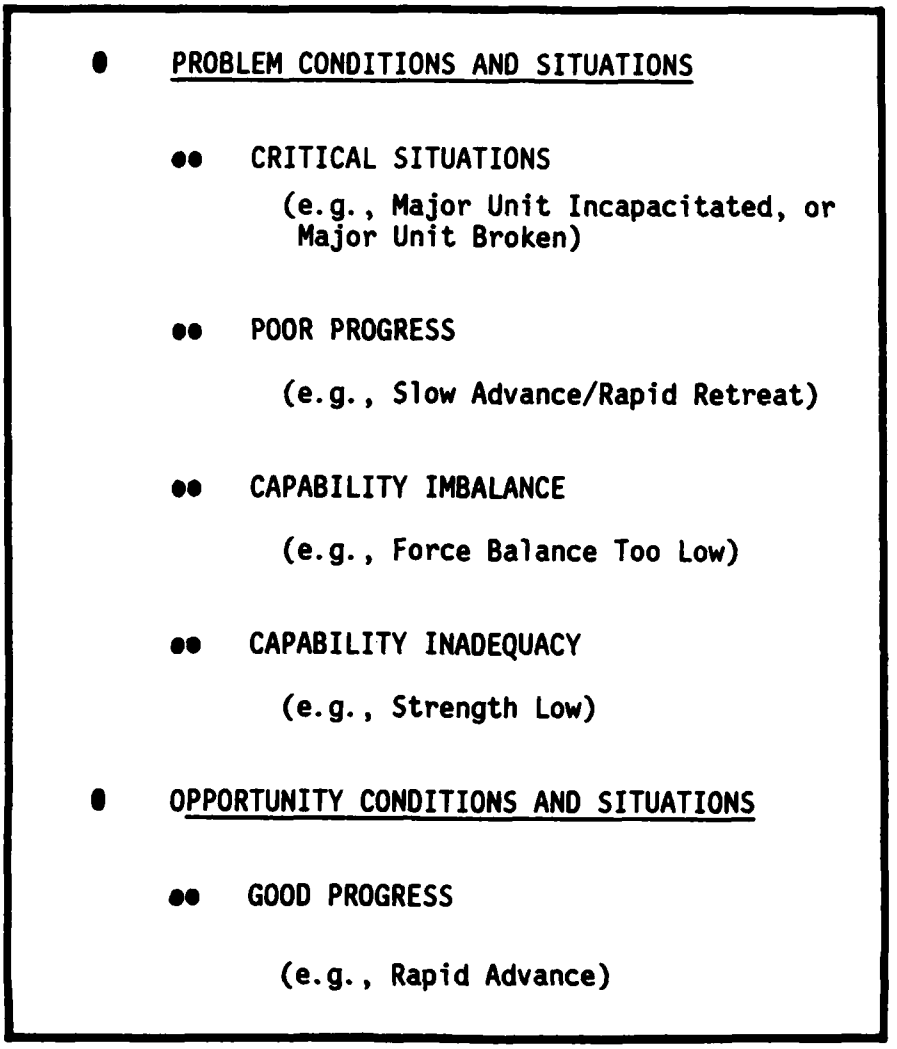


Figure III-2. Indicating Condition Types

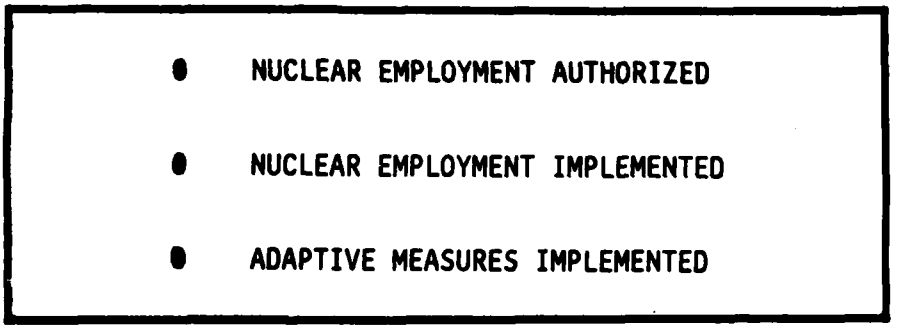


Figure III-3. Provocation Types

elements at some time in the future. It is reasonable to postulate that the (perceived) "level" or "degree" of nuclear threat is directly related to the (perceived) likelihood of nuclear weapons employment (at some future time). Thus, as a first approximation,

$$NTI \sim P(N) \qquad \text{(III-1)}$$

where:

NTI = Nuclear Threat Index

P = A probability measure on battlefield events

N = The battlefield event 'enemy employment of nuclear weapons'

However, as will become apparent below, it is more convenient to work with the odds of nuclear employment than with direct probabilities. Thus, we define:

$$NTI = \frac{P(N)}{P(\bar{N})} = \frac{P(N)}{1-P(N)} \qquad \text{(III-2)}$$

where:

$\bar{N}$ = the logical complement of N, i.e., "no enemy employment of nuclear weapons"

Note that under this approach, NTI may assume any non-negative value. Moreover,

$$NTI = 0.0 \text{ if and only if } P(N) = 0.0 \qquad \text{(III-3)}$$

and,

$$NTI \left\{ \begin{matrix} > \\ = \\ < \end{matrix} \right\} 1.0 \text{ if and only if } P(N) \left\{ \begin{matrix} > \\ = \\ < \end{matrix} \right\} P(\bar{N}) \qquad \text{(III-4)}$$

These provide a convenient characterization of certain key likelihood conditions. Finally, the direct probabilities can always be recovered from odds via the following formulas:

$$P(N) = \frac{NTI}{1 + NTI} \qquad \text{(III-5a)}$$

$$P(\bar{N}) = \frac{1}{1 + NTI} \qquad \text{(III-5b)}$$

It should be noted that the event N (i.e., 'enemy employment of nuclear weapons') has many suppressed dimensions including the magnitude of

the employment, the types of targets attacked, and the time of the employment. Thus, N is best regarded as a union of basic nuclear events defined by specific values along these various dimensions (including, e.g., 'medium-sized, broad employment within 24 hour,' as well as 'small-sized counter-maneuver employment within 1 hour'). Such distinctions in the magnitude, object, and imminence of the nuclear threat cannot be treated in INWARS. The single nuclear event N is therefore more properly interpreted as: 'enemy employment of some nuclear weapons against some friendly target within t hours' where $t \geq 0$ is some operationally significant time. The interpretation of N has no computational significance; it is important from the standpoint of data preparation, however.

3. Updating the Nuclear Threat Index

As a UOS component, the Nuclear Threat Index is essentially a mental state variable. It should be cnanged whenever there is a significant change in the nuclear indications or provocations it summarizes. Thus, C^2I elements may wish to update their Nuclear Threat Index upon receipt of information relating to changes in indicating activities or conditions, or upon undertaking a provocative action. Given the probabilistic interpretation of the threat index, it is natural to formulate the updating process in terms of Bayesian revision of probabilities (and odds). Specifically, let 'I' designate an indicating event (activity or condition) relevant to the nuclear threat. Upon receipt of information that an instance of I has occurred, the probability of the nuclear event (i.e., P(N)) should be revised to the conditional probability of the nuclear event given that I has occurred (i.e., P(N/I)). As is well known, the revised (posterior) probability is related to the original (prior) probability by Bayes' Theorem:

$$P(N/I) = \frac{P(I/N)*P(N)}{P(I/N)*P(N) + P(I/\bar{N})*P(\bar{N})} \qquad \text{(III-6)}$$

Since the Nuclear Threat Index is defined by (III-2) in terms of odds rather than probabilities, we are interested in the ratio of the conditional probabilities P(N/I) and P(N/I), both conditioned on the occurrence of I. Thus, using (III-6), the revised Nuclear Threat Index, NTI',

may be computed as follows:

$$NTI' = \frac{P(N/I)}{P(\bar{N}/I)} = \tag{III-7a}$$

$$= \left(\frac{P(I/N)*P(N)}{P(I/N)*P(N) + P(I/\bar{N})*P(\bar{N})}\right) = \left(\frac{P(I/\bar{N})*P(\bar{N})}{P(I/N)*P(N) + P(I/\bar{N})*P(\bar{N})}\right) \tag{III-7b}$$

$$= \frac{P(I/N)*P(N)}{P(I/\bar{N})*P(\bar{N})} = \tag{III-7c}$$

$$= \left[\frac{P(I/N)}{P(I/\bar{N})}\right]* NTI \tag{III-7d}$$

This derivation further illuminates the choice of an odds formulation rather than a direct probability formulation. Clearly, the revision computation for the odds formulation (III-7d) is much simpler than for the direct probability formulation (III-6). This is especially true if the likelihood ratio $P(I/N)/P(I/\bar{N})$ is stored as a single value, $\lambda(I)$, in which case we have:

$$NTI' = \lambda(I)*NTI \tag{III-8}$$

In fact, the likelihood ratio $\lambda(I) = P(I/N)/P(I/\bar{N})$ can be directly estimated as a measure of the relevance and evidential strength of the activity or condition I as an indicator of N. This provides a single-parameter characterization of the various types of relevant information discussed in Section B.1 above. Two basic considerations in setting $\lambda(I)$ include: (1) the operational linkages between event I and enemy nuclear employment (Must I necessarily be undertaken to prepare for nuclear employment? Could I have been undertaken with some <u>other</u> purpose in mind then nuclear employment?), and (2) the possibility of incorrect information about the event I

(Is it possible that the information source incorrectly perceived a different event as an occurrence of I?). To the extent that a strong operational relationship exists and there is little possibility of error in perceiving I, $\lambda(I)$ should be set "high" (above 1). Of course, $\lambda(I)$ should generally be set lower than λ ("IMPACT OF NUCLEAR WEAPONS ON TARGET") which reflects an upper limit on relevance to the nuclear threat. Once initial values have been assigned for all appropriate events, they should be reviewed and adjusted as needed to establish consistency among the $\lambda(I)$'s. That is, stronger or more relevant I's should have been assigned higher $\lambda(I)$ values.

C. DEVELOPING OPERATIONS UNDER THE PERCEIVED NUCLEAR THREAT

As C^2I elements develop operations to accomplish missions assigned by their superiors, they may wish to consider the (perceived) level of nuclear threat. Some C^2I elements may operate differently under different levels of nuclear threat. In this section, influence of the Nuclear Threat Index on operations development will be presented. Influences on ground and air operations development processes are discussed in Sections C.1 and C.2, respectively.

1. Influence of Perceived Nuclear Threat on Ground Operations Development

The ground operations development process offers a variety of points at which consideration of perceived nuclear threat can be introduced. Two basic points of influence will be treated in INWARS: (1) the influence of nuclear threat on the appraisal of the suitability of ground concepts of operation; and, (2) the influence on the allocation of nuclear weapons among subordinates (for planning).

a. Influence on Suitability Appraisal of Ground Concepts of Operation

A direct and natural way to introduce nuclear threat perception into the ground operations development process is simply to include threat index thresholds among the list of suitability conditions of some or all ground concepts of operation. Under this approach, if the Nuclear

Threat Index exceeds the threshold associated with a particular concept, that concept will be deemed "unsuitable" and not explored further. By setting appropriate threat index thresholds, the user can impose a wide variety of nuclear doctrines on the INWARS C^2I elements. For example, setting the thresholds of all concepts at high levels imposes a relative indifference to the nuclear threat during operations development -- concepts of operation will seldom be judged unsuitable on the basis of nuclear threat. By contrast, setting the thresholds at low levels for some concepts of operation imposes a judgment that those concepts are inappropriate in situations having a moderate to high nuclear threat. This might, for example, be appropriate for concepts of operation requiring significant massing of forces (e.g., a "classic" large-scale breakthrough operation).

b. Influence on Allocation of Nuclear Weapons Among Subordinates (for Planning)

During the detailing of a developed concept of operation at any level of command, a variety of resources must be allocated among subordinates. Included among these resources are nuclear weapons. This allocation is for planning purposes only: subordinates are permitted to plan for the employment of the allocated weapons, they are not authorized to actually employ them. Nonetheless, the allocation for planning is important since it constrains what nuclear weapons may be requested at each level.

As described in the Level III Specifications (Volume V, Chapter IV, Paragraph F.3.d, P.IV-22), the allocation of nuclear munitions among a particular C^2I element's subordinates was to be accomplished by a simple weighted "distribution" of those nuclear munitions allocated by the C^2I element's superior. The weighting (or "relative share") received by a particular subordinate was to be derived from the role of that subordinate in the overall operation. This scheme reflects the relative operational importance of the subordinates, but it does not treat relative differences in nuclear threat faced by those subordinates. Neither does it permit the superior to "hold back" discretionary munitions for allocation later in the operation. The more complex scheme of Figure III-4 enables such dependencies.

STEP 1: COMPUTE PORTION TO BE ALLOCATED AMONG SUBORDINATES

$$SP = \left[\frac{NTI}{1 + NTI}\right] * TA \quad (= P(N)*TA) \qquad \text{(III-9)}$$

where:

SP = SUBORDINATE PORTION OF TOTAL ALLOCATION
TA = TOTAL ALLOCATION (FROM SUPERIOR)

STEP 2: ALLOCATE SUBORDINATE PORTION IN RELATION TO SUBORDINATES' OPERATIONAL IMPORTANCE AND NUCLEAR THREAT PERCEPTION

$$SA_i = \left[\frac{(NTI_i * R_i)}{\Sigma_i (NTI_i * R_i)}\right] * SP \qquad \text{(III-10)}$$

where:

SA_i = SUBORDINATE i ALLOCATION
NTI_i = SUBORDINATE i NUCLEAR THREAT INDEX
R_i = SUBORDINATE i ROLE IMPORTANCE FACTOR
SP = SUBORDINATE PORTION (COMPUTED IN STEP 1)

Figure III-4. Allocation of Nuclear Munitions for Planning

By Step 1 of this allocation process, the relative portion of the total nuclear allocation from the superior to be distributed among the subordinates is directly proportional to NTI/(1+NTI) which, by Equation III-5a, is just P(N). Thus, the more likely a nuclear event -- i.e., the higher the perceived nuclear threat -- the more munitions will be allocated among subordinates for their planning purposes.

By Step 2 of the allocation process, the nuclear munitions actually allocated to a particular subordinate are determined by both the relative operational importance of his role in the operation and by the nuclear threat he perceives. This enables a less important but more highly threatened subordinate to be allocated just as many nuclear munitions as a more important but less threatened subordinate.

c. Other Potential Influences on Ground Operations Development

The two influences discussed above provide only a minimal treatment of the gross impact of nuclear threat perceptions on the development of ground operations. It should be noted, however, that there is considerable room to include more influences in this area: the Nuclear Threat Index could be introduced as a factor in virtually every processing and assessment step in the ground operations development process.

2. Influence of Nuclear Threat Perception on Air Operations Development

The simplified treatment of air functions and air operations development in INWARS does not offer as many possibilities for introducing the influence of nuclear threat perception. One basic influence on air operations development -- on the nuclear withhold -- is treated.

The influence of nuclear threat perception on the nuclear withhold is realized during the theater level detailing of the concept of the air operation. As described in the Level III Specifications (Volume V, Chapter VI, Section B.2), theater level detailing is concerned with allocating air effort among specific air missions on an ATAF/TAA-by-ATAF/TAA basis. As a part of this allocation effort, a specific nuclear withhold (QRA) constraint must be set in terms of quantity of (nuclear-capable) aircraft to be withheld in each ATAF/TAA. The withhold procedure outlined in the Level III Specifications utilized a table look-up based on the level of nuclear threat. A simpler form will be used which is based on the

operation, alternative U.S. concepts of operation and suggestions for war assumption that the magnitude of the withhold is proportional to the nuclear threat:

$$WH = \left(\frac{NTI}{1 + NTI}\right) * TWH \qquad \text{(III-11)}$$

where:

WH = Quantity of aircraft withheld

TWH = Total (maximum) withhold desired under a "certain" nuclear threat

This approach is computationally simpler than the table look-up approach. Though less flexible, it is also less demanding in terms of user-input requirements.

D. ADAPTING OPERATIONS TO CHANGES IN THE PERCEIVED NUCLEAR THREAT

As an operation is carried out, it may require certain changes to adapt to the course of the conflict. Such alterations to ongoing operations may be regarded as responses to contingencies defined and recognized in terms of certain key situation features. Indeed, the execution and control of an operation is treated as a process of recognition and response to contingencies in INWARS.

One important class of contingencies involves changes in the perceived nuclear threat. The recognition of such nuclear threat contingencies is easily formulated in terms of threshholds on the Nuclear Threat Index: whenever the index crosses a threshhold (up-crossing or down-crossing), a nuclear threat contingency has been recognized. Responses to a nuclear threat contingency range from the implementation (or de-implementation) of certain specialized adaptive measures, to the complete redevelopment of an ongoing operation. (See Figure III-5.) Adaptive measures treated in INWARS are discussed in Section D.1 below. Sections D.2 and D.3 concern operation-specific adjustments as well as the potential need to redevelop an ongoing operation. Section D.4 then highlights certain other actions which may occur in the process of responding to a change in nuclear threat.

ADAPTIVE MEASURES

- CHANGE NUCLEAR READINESS STATE
- PROTECT NUCLEAR DELIVERY CAPABILITIES

ADJUSTMENTS TO ONGOING OPERATIONS

- ADJUST TARGET PRIORITIES
- ADJUST ALLOCATION OF NUCLEAR WEAPONS AMONG SUBORDINATES
- ADJUST NUCLEAR WITHHOLD

SUBSTANTIVE CHANGES TO ONGOING OPERATIONS

- REDEVELOP OPERATION
- CONSIDER NUCLEAR EMPLOYMENT

Figure III-5. Potential Responses to Changes in the Nuclear Threat in INWARS

1. Potential Adaptive Measures in INWARS

As used here, 'adaptive measure' refers solely to an action or activity undertaken to "adapt" to a changing nuclear threat. Typically, such measures may be concerned with either: (1) reducing the vulnerability of force elements to a nuclear attack, or (2) preserving the ability to respond "in kind" to a nuclear attack. Implementation of such measures yields a benefit in the event that a nuclear attack occurs. However, if no attack occurs, little (if any) benefit accrues; indeed, most adaptive measures bear a "cost" in terms of decreased capability to prosecute conventional operations in an effective and efficient manner. Thus, it is as important to de-implement adaptive measures in response to a declining threat as it is to implement them in response to an increasing threat.

a. Increase/Decrease Nuclear Readiness State

At any point in time, each force element in INWARS is in a certain nuclear readiness state. This state provides a representation of various readiness actions taken by units to reduce their vulnerability to the effects of a nuclear attack: dispersal of maneuver units, and protection of resources of service support units are examples. The readiness state representation is implicit in that the execution of the associated activities is not actually modeled in INWARS, only the results of their execution. Two broad forms of results are treated in INWARS: (1) reduction of the effect of a nuclear attack (the "benefit" of the measure), and (2) degradation of conventional capability and effectiveness (the "cost" of the measure). These results will typically vary with the type of force element involved; thus, unit readiness state is used together with unit type code to index into a table of readiness state modifier factors. Each of these modifiers may be regarded as a scaling factor for some effects process -- its application scales the effect (computed relative to a reference readiness state). With this approach, the scaling factors themselves can vary over different types of force elements. Moreover, any or all of the scaling factors can be set to 1.0 in order to "nullify" the treatment of readiness state impacts for that particular type of unit.

b. Protect Nuclear Delivery Capabilities

As the nuclear threat increases, C^2I elements might wish to protect nuclear delivery capabilities in order to maintain an ability to respond "in kind" to any enemy nuclear attack. Because of the limited and largely implicit treatment of missile and artillery operations and activities in INWARS, this type of adaptive measure can be made explicit only for nuclear-capable aircraft. Measures to protect such aircraft in INWARS include: (1) dispersal to "primitive" air bases, (2) dispersal to "safe" air bases, and (3) "vertical dispersion."

The first of these -- dispersal to "primitive" air bases -- will be treated implicitly as a part of the nuclear readiness state of the air base clusters. This will reduce the loss of aircraft if the air base cluster sustains a nuclear attack; it will also reduce the rate at which aircraft can be launched by that air base cluster (thus reflecting the more limited facilities of "primitive" air bases).

Dispersal to "safe" bases and vertical dispersion will be treated explicitly by means of special missions for air mission packages. The first measure is handled by a "fly-to" mission together with an associated "safe" air base cluster as the destination. The vertical dispersion measure is handled by a "disperse" mission which causes aircraft to leave the air base clusters while avoiding an air battle.

2. Potential Adjustments to Ongoing Operations in INWARS

In addition to the adaptive measures discussed above, C^2I elements may wish to change certain aspects of their ongoing operations. Thus, adjustments to ongoing operations are another type of response to changes in the nuclear threat. Three types of adjustments will be treated in INWARS: (1) adjustment of target priorities, (2) adjustment of nuclear allocations, and (3) adjustment of nuclear withhold.

a. Adjust Target Priorities

It may be desirable for C^2I elements to alter the priorities they assign to enemy targets as the perceived nuclear threat varies. Of particular interest here are the targeting priorities assigned to enemy nuclear-capable delivery units such as surface-to-surface missile pools,

artillery pools, and air base clusters. The ability to drastically alter -- either raise or lower -- the targeting priorities of such units enables the user to examine differing policies in this regard (e.g., "don't target for fear of provoking a nuclear attack" versus "always target with highest priority to reduce enemy attack capability"). This adjustment is implemented by including two sets of target priorities in each concept of operation: one set each for "low threat" (conventional) and "high threat" (nuclear) situations. A threshhold value on the Nuclear Threat Index provides the criterion for which set to use.

b. Adjust Allocation of Nuclear Weapons Among Subordinates (for Planning)

As was noted in Paragraph C.1.b, above, the perceived level of nuclear threat influences the allocation of nuclear weapons among subordinates for planning. Both the portion allocated to subordinates and the relative allocations may be affected (recall Figure III-4). Thus, as the nuclear threat increases, a given C^2I element will wish to allocate more weapons to his subordinates for planning; moreover, if the nuclear threat shifts among his subordinates, he may wish to adjust the relative allocation among the subordinates.

In principle, such a reallocation might be desirable with every change in the Nuclear Threat Index. In practice, however, only significant re-allocations would be actually carried out. Accordingly, in INWARS, this type of re-allocation will not be worked out for every change in the Nuclear Threat Index. Rather, the allocations will be recomputed as a part of each C^2I element's periodic review of the situation.

c. Adjust Nuclear Withhold

As was noted in Paragraph C.2., above, the perceived level of nuclear threat influences the number of aircraft to be withheld against the possibility of a nuclear attack. Thus, as the nuclear threat varies, the theater C^2I element may wish to withhold more or less aircraft. In principle, the withhold quantity could be recomputed with every change in the Nuclear Threat Index. However, as with nuclear allocations, adjustments to the withhold will only be recomputed during the theater C^2I element's periodic review of the situation.

3. The Possibility of Redeveloping Operations

If the perceived nuclear threat changes extensively and/or rapidly, it may be difficult or impossible to adapt and adjust ongoing operations to the new threat level. In such cases, a redevelopment of ongoing operations may be required: the C^2I element must go through the whole operations development process using the existing operations directive, but taking account of the changes in the battlefield situation. Redevelopment is obviously a very extreme action. It should be reserved for the most significant changes in the perceived nuclear threat.

The basic nuclear threat criterion for the redevelopment of an ongoing operation is the violation of the nuclear threat suitability threshhold for that operation. As discussed in Section C.1.a, above, the nuclear suitability threshhold of a concept of operation characterizes when it is "reasonable" to consider that concept (namely, when the nuclear threat index is below the suitability threshhold). Thus, when this threshhold is violated, it is "reasonable" to consider changing to another concept of operation. Such consideration will not necessarily change the ongoing operations; it will only provide an opportunity to do so.

4. Other Actions in Response to a Change of Nuclear Threat

Operationally significant changes in the Nuclear Threat Index may result in the implementation or de-implementation of certain adaptive measures as well as adjustments or redevelopment of the ongoing operation. Certain other actions may also be required in responding to such a change. These include reporting activities and consideration of nuclear employment.

Each C^2I element will report significant changes in its Nuclear Threat Index to its superior and subordinates. (Significance is defined here in terms of having made some response -- adaptive measure, operational adjustment, or redevelopment). By this means, information about the nuclear threat propagates throughout the force. Of course, since communications processes take time, the information does not propagate instantaneously.

Finally, a rising nuclear threat may stimulate a C^2I element to consider the employment of nuclear weapons himself. This possibility is

discussed in more detail in Chapter IV, Section B.1.a.(1), below. The aim here is to provide the capability to establish a linkage between threat and response.

E. RESPONDING TO A NUCLEAR ATTACK

The discussion thus far has focussed on potential nuclear attacks. However, even in the event that this potential -- the nuclear threat -- is realized by an actual attack, C^2I elements respond in accordance with these same procedures. It will be recalled from Figure III-1 that "impact of nuclear munitions on target" is one of the relevant indicating activities; reports or perceptions of this event will cause a dramatic rise in the Nuclear Threat Index. In effect, a nuclear attack is perceived as a "very high" level of nuclear threat by a C^2I element in INWARS. Thus, it will respond by: (1) implementing appropriate adaptive measures (typically, highest readiness states would be implemented), (2) adjusting and/or redeveloping ongoing operations, (3) reporting to other C^2I elements as appropriate, and, perhaps, (4) considering retaliatory nuclear employment. Notice that actions required to respond under these procedures will depend on what adaptations and adjustment have been implemented previously in response to perceived increases in nuclear threat. Thus, a "surprised" C^2I element will have more to do in response than will a "prepared" C^2I element. For example, a redevelopment of operations may generally be necessary in responding to a nuclear attack; however, if the perception of the threat was good enough -- and the response policies conservative enough -- redevelopment might have occurred previously and thus not be required immediately after the attack.

CHAPTER IV
THE NUCLEAR DECISION PROCESS IN INWARS: OVERALL STRUCTURE

A. INTRODUCTION

This chapter begins a discussion of the nuclear decision process and its treatment in INWARS. It is important to emphasize that much more is involved in this "decision process" than just a selection among alternatives. Selection is involved, but the modeling approach must also treat: (1) the conditions and events which can stimulate the decision process; (2) the nature of the alternatives including, in particular, the process by which they are generated, designed and developed; and (3) the processes by which actions are formulated (and scheduled) to implement the selected alternative.

The various activities, conditions, and events which may stimulate the nuclear decision process in INWARS are presented in Section B below. Once initiated, the decision process attempts to design a specific nuclear employment which is appropriate to the C^2I element's situation, the activity, condition, or event which stimulated the process, and the operative political or military constraints. These employment design procedures are discussed in detail in the next chapter, but are here treated as a "black box". Once a nuclear employment has been designed, the C^2I element must determine what activities are required to implement it. This determination is somewhat complicated by the involvement of C^2I elements at several echelons as discussed in Chapter II; the determinations are presented in Section C, below.

B. STIMULI TO CONSIDER NUCLEAR EMPLOYMENT

Ultimately, any consideration of nuclear employment can be traced back to the perception by some C^2I element of a situation which falls under the doctrinally sanctioned conditions for nuclear employment. Recognition of such a situation by a C^2I element is thus a direct stimulus for that element to consider nuclear employment. In addition to recognition of direct

stimuli, receipt of a request for nuclear authorization (from a subordinate C^2I element) or authorization for nuclear employment (from a superior C^2I element) will also stimulate a C^2I element to consider nuclear employment. Requests and authorizations may therefore be regarded as derived stimuli (since they derive from -- and are dependent on -- some direct stimulus).

1. Direct Stimuli

From a modeling point of view, it is necessary to provide for a variety of battlefield conditions and events which may or may not serve as direct stimuli at the discretion of the user. This enables the user to control the "doctrinal attitudes" of the C^2I elements towards nuclear weapons (e.g., "general purpose remedy" versus "solution of last resort"). Note that the direct stimuli do not determine whether nuclear weapons will (or will not) be used; they merely provide an occasion for that decision to be made. Conditions and criteria for employment may be more restrictive.

The particular direct stimuli to be provided in INWARS are discussed in two basic categories distinguished on the basis of whether the stimuli pose: (1) problems to be solved, or (2) opportunities to be exploited. Of course, within each class there are gradations: some problems are more severe or immediate than others, and some opportunities are more lucrative than others. Figure IV-1 presents categories and subcategories of direct stimuli in INWARS. These are discussed in the following paragraphs.

a. Problem Situations

Problem situations are characterized by battlefield conditions or events which may hinder or preclude the attainment of assigned objectives. Problem situations may vary in severity (degree of hindrance and extent of actions required to rectify) and immediacy (time frame within which the problem must be rectified to prevent adverse impact). Problem situations able to stimulate consideration of nuclear weapons employment would typically be relatively severe; they may be relatively immediate as well.

PROBLEMS

- CRITICAL SITUATION
  - -- SECTOR COLLAPSE
  - -- "VERY HIGH" NUCLEAR THREAT
  - -- ENEMY USE OF NUCLEAR WEAPONS
- POOR PROGRESS
  - -- FEBA POSITION/MOVEMENT
  - -- MILESTONES IN OPERATION
- INADEQUATE CAPABILITY
  - -- CONVENTIONAL GROUND FORCE
  - -- TNF
  - -- AIR SUPPORT
  - -- COMBAT SERVICE SUPPORT
- DOMINATED CAPABILITY
  - -- CONVENTIONAL GROUND FORCE
  - -- TNF
  - -- AIR SUPPORT

OPPORTUNITIES

- LUCRATIVE TARGET
  - -- TNF ELEMENT
  - -- C^2I ELEMENT
  - -- MANEUVER ELEMENT
  - -- COMBAT SERVICE SUPPORT ELEMENT
- LUCRATIVE SITUATION
  - -- SUCCESS EXPLOITATION

Figure IV-1. Categories of Direct Stimuli to Consider Nuclear Employment in INWARS

1) Critical Situations

Critical situations pose very severe and immediate problems, at least for some C^2I element. Treatment as a critical situation should be reserved for those problems in which defeat appears imminent and can only be avoided by extreme action. Critical situations may be defined in terms of violations of thresholds or occurrences of certain events. Three types of critical situations will be treated in INWARS: (1) collapse of a principal subordinate force element, (2) very high nuclear threat (violation of a critical threat threshold on the Nuclear Threat Index), and (3) enemy employment of nuclear weapons against a principal subordinate force element.

2) Poor Progress

Poor progress poses a less severe and immediate problem than a critical situation; however, poor progress may lead to a critical situation if not rectified. Progress is "poor" when actual progress towards assigned objectives is significantly "worse" than expected progress. In INWARS, progress expectations are implied in the phasing of an operation; in addition, specialized progress expectations may be inherent in certain parameters associated with an operation (desired movement rate is a prime example). Thus, poor progress stimuli will be characterized in terms of: (1) phase objectives missed (or number of phases by which actual progress lags expected progress), and/or, (2) significant deviations from desired rate parameters.

3) Inadequate Capabilities

Inadequate capability conditions exist whenever some of the capabilities controlled by a C^2I element fall significantly below the standard deemed adequate for that C^2I element's ongoing operation. Note that it is the overall capabilities of large force elements (echelons above division) which are of concern here. For this reason, considerable aggregation of capabilities by function is appropirate. In INWARS, four broad classes of capabilities will be considered: (1) conventional ground combat capability; (2) conventional air support capability; (3) tactical nuclear weapon employment capabilities; and, (4) combat service support capabilities.

4) Dominated Capabilities

Dominated capability conditions exist whenever some of the capabilities controlled by a C^2I element are significantly exceeded by corresponding enemy capabilities. This is much like an inadequate capability condition except that the defining threshold is set with respect to enemy capabilities rather than an internal operational standard. Again, capabilities are aggregated functionally in terms of: (1) conventional ground combat capability; (2) conventional air support capability; (3) tactical nuclear weapon employment capability; and, (4) combat service support capabilities.

b. Opportunity Situations

Opportunity situations are characterized by battlefield conditions or events which may facilitate the attainment of assigned objectives if properly exploited. Nuclear employment may seem a rather extreme approach to exploiting an opportunity; however, as was noted earlier, the modeling aim is to provide a variety of stimuli which may be selected by the user to represent a particular set of nuclear attitudes and policies. Accordingly, two basic types of opportunities are provided which may stimulate nuclear considerations: (1) lucrative target acquired, and (2) good progress.

1) Lucrative Target Opportunity

The acquisition of a lucrative target presents a potential opportunity to employ nuclear weapons. Among the various types of targets treated in INWARS, not all may be readily exploitable with nuclear weapons. Moreover, which target types are "lucrative" at any given point in time may depend on which C^2I element has acquired it, the type of operation that C^2I element is conducting, and the operative set of target priorities. To avoid this situation dependence, lucrative targets will be specified in terms of: (1) lowest priority level considered lucrative, and (2) types of targets to be considered as lucrative targets for exploitation by means of nuclear weapons.

2) Good Progress Opportunity

Good progress opportunities concern situations where actual progress towards assigned objectives is considerably better than expected progress. This is, in essence, the inverse of the poor progress problem discussed above. In particular, it is assessed and recognized in terms of the same types of parameters as the poor progress problem: differences between actual and expected phase completion, and operating parameters. A "good" progress opportunity is recognized if actual progress is significantly better than expected progress.

2. Derived Stimuli

In general, lower level C^2I elements do not have the authority to directly carry out nuclear employments. As is described in more detail below, the authority to employ nuclear weapons must be requested from superior C^2I elements. Thus, receipt of a nuclear employment request from a subordinate provides a stimulus to consider nuclear employment along the lines requested. Eventually in this chain of requests, a C^2I element may be reached with the ability to authorize employment of nuclear weapons. If authorization is granted, it is implemented by means of a nuclear employment authorization message to the requestor. Receipt of such an authorization thus provides yet another type of stimulus to consider nuclear employment.

3. Stimuli as Inputs to Nuclear Employment Considerations

It is important to note that a C^2I element does not consider nuclear employment in a vacuum. Like any other mental processes, these considerations have access to all information in the C^2I element's Understanding of the Situation (UOS). This provides an extensive base of information ranging from general policies and procedures for nuclear employment to specific information about the situation (including, in particular, potential targets for nuclear weapons). However, it should also be noted that the considerations are not even initiated until a considerable amount of information is developed about the problem or opportunity to be dealt with by the (potential) employment of nuclear weapons. Nuclear weapons might be applied differently to solve, e.g., a poor progress problem, than

to exploit a lucrative target opportunity. But this "diagnosis" of the situation has already been made when the considerations are initiated, and can thus be utilized fully by the design processes. Since this diagnosis is implicit in the stimuli, they may essentially be regraded as "input" to the employment conditions.

C. ACTIONS TO IMPLEMENT NUCLEAR EMPLOYMENT CONSIDERATIONS

The result of employment consolidation is, in essence, a decision about whether or not to employ nuclear weapons and, if so, where and how. This decision is principally expressed in the form of a nuclear package specification. To implement the decision, the package specification must generally be communicated to other TNF decisionmakers; additional directives to TNF implementors may also be required. The structure of a nuclear package in INWARS is discussed in C.1; C.2 and C.3 present the actions involved in implementation and the logic by which they are selected.

1. Nuclear Packages in INWARS

The notion of "nuclear package" as used in INWARS corresponds in some respects to the notion of "nuclear package" as used in actual nuclear planning (as described, e.g., in Chapter 6 of FM 6-20, Fire Support In Combined Arms Operations, September 1977). In both cases, a package provides a way of specifying -- and manipulating -- a discrete grouping of nuclear weapons for employment within time and space limitations for a particular purpose.

In INWARS, a nuclear package is specified by means of an information structure such as that shown in Figure IV-2. Note that, like a "real" package, the specification includes a purpose, certain timing information, and a listing of munitions to be utilized. The package purpose is specified in terms of the particular type or "concept of employment" under which the package was designed. The timing information includes both a time frame during which the package must be utilized and a timespan within the time frame during which the actual delivery ("pulse") must be completed.

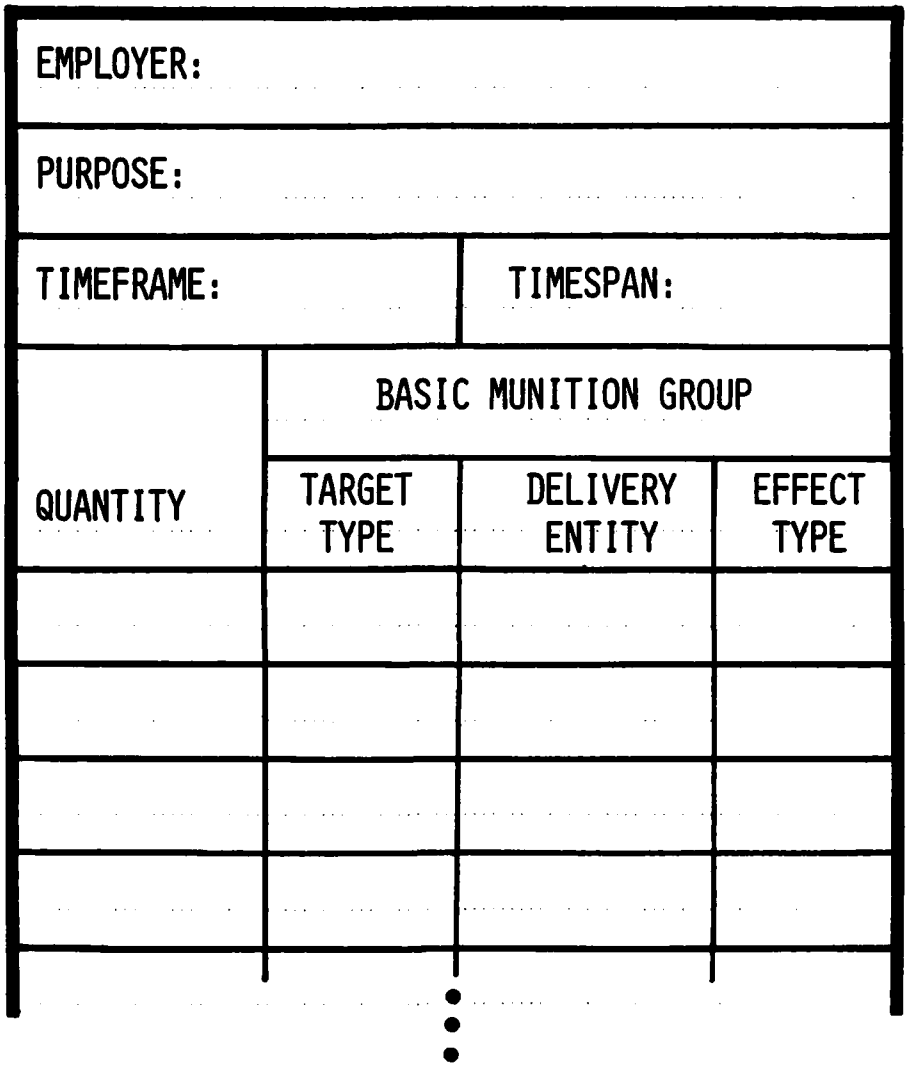


Figure IV-2. Nuclear Package Structure in INWARS

Unlike "real" packages, however, INWARS packages do not explicitly specify an area within which the package is to be employed. Instead, an "employer" is specified -- this is the C^2I element which would exercise control over the employment of the package. Since all C^2I elements have an area of operations, specifying a package employer implicitly specifies the area of employment to be the employer's area of operations. Any additional spatial constraints on package employment would be specified externally to the package itself (e.g., in the form of military or political policy constraints).

Also unlike "real" packages, INWARS packages specify the munitions to be employed in the form of "Basic Munitions Groups". Each Basic Munition Group prescribes a particular grouping of munitions to be applied by a particular type of delivery entity to achieve a particular type of effect against a particular type of target. The concept is illustrated in Figure IV-3. Basic Mission Group definitions would be provided as a part of the simulation inputs, thus giving the user control over this aspect of the nuclear decision process.

It is apparent that the use of Basic Munitions Groups reduces the ability of an INWARS C^2I element to tailor an attack to the particular features of target. However, it reduces the potential variety of alternative packages to a more manageable scale. It also provides a natural association between targets, available means of delivery, and desired levels of effect; this facilitates the development of targeting heuristics, as will be discussed in Chapter V, below.

2. Repertoire of Nuclear Employment Implementation Actions

C^2I elements involved in the processes of nuclear employment have a limited range of actions at their disposal to implement the decisions they make in the nuclear context. As a whole, they may: (1) request package authorization, (2) authorize package employment, (3) deny package employment, (4) direct subordinate Nuclear Supply Point Clusters to issue specified nuclear munitions to designated entities, and/or (5) direct subordinate delivery entities (artillery, missile, or air) to deliver specified nuclear munitions against designated targets. Note that all of

DELIVERY ENTITY	ARTILLERY			MISSILE			AIR		
EFFECT / TARGET TYPE	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 1	LEVEL 2	LEVEL 3	LEVEL 1	LEVEL 2	LEVEL 3
C^2I ELEMENT									
MANEUVER BDE/REGT (COMMITTED)									
MANEUVER BDE/REGT (RESERVE/REINFORCING)									
AIR BASE CLUSTER									
COMBAT SERVICE SUPPORT COMPLEX									
NUCLEAR CAPABLE DELIVERY ENTITY									
NUCLEAR WEAPONS SUPPLY POINT CLUSTER									

(EACH CELL IN THE MATRIX WOULD SPECIFY A FIXED GROUP OF MUNITIONS INTENDED TO BE DELIVERED BY THE SPECIFIED ENTITY TO ACHIEVE THE SPECIFIED LEVEL OF EFFECTS AGAINST THE SPECIFIED TYPE OF TARGET)

Figure IV-3. Basic Munitions Groups

these actions are conducted via communications using the message structures discussed above in Chapter II. Note also that the actions are not mutually exclusive -- thus, a C^2I element faces a decision concerning which group of messages to send, not just which message. As will be seen, this is not a hard decision -- there are definite rules about what to do; it is, however, a rather complicated decision since there are several influencing factors which must be checked.

3. Conditions Influencing the Actions to Implement

This section surveys the factors and conditions which influence the selection of actions to implement a nuclear employment decision.

- Context: An important determinant of actions to implement is the context in which the considerations are being made. As discussed above, context is defined in terms of the nature of the stimulus to consider nuclear employment (direct perception, request from subordinate, or authorization from superior).
- Decision: Of course, the decision as to whether or not to employ nuclear weapons at all is a principal influence in this area. As noted earlier, this decision is implicit in the size of the package designed -- a null ("empty") package implies a decision to not employ nuclear weapons. In certain contexts, even a decision to not employ may require implementing activities.
- Authority: Whether or not a C^2I element has the authority to employ nuclear weapons also influences the actions to implement. The authority may be intrinsic or granted by a higher C^2I element via an authorization; it may be limited in various ways including employment within the constraints of a specific nuclear package. In any case, authority to employ is the principal determinant of whether implementing actions flow "upwards" (requests) or "downwards" (authorizations) in the chain of command.
- Nuclear Capability: A C^2I element has nuclear capability to the extent that it directly controls nuclear supply points or delivery entities (i.e., has such entities as immediate subordinates). In authorization contexts, C^2I elements with nuclear

capability must determine how, if at all, it is to be utilized in executing the authorized package. More specifically, such C^2I elements must determine whether or not munitions must be provided to subordinates, and also whether or not directly controlled delivery entities are to have a role in the delivery of the Basic Munitions Groups of the authorized package.

4. Relation Between the Conditions and Actions

As was suggested earlier, the determination of actions to implement a nuclear employment is somewhat involved, but follows fixed rules. These rules are presented in the form of a decision table in Figure IV-4.

CONTEXT	DIRECT								REQUEST								AUTHORIZATION							
DECISION	EMPLOY				NOT EMPLOY				EMPLOY				NOT EMPLOY				EMPLOY				NOT EMPLOY			
AUTHORITY	Y		N		Y		N		Y		N		Y		N		Y		N		Y		N	
NUCLEAR CAPABILITY	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC	C	NC
DO NOTHING					●	●	●	●													●	●		
FORMULATE & TRANSMIT REQUEST TO EMPLOY			●	●							●	●												
FORMULATE & TRANSMIT DENIAL OF REQUEST													●	●	●	●								
FORMULATE & TRANSMIT AUTHORIZATION TO EMPLOY	▲	●							●	●							▲	●						
FORMULATE & TRANSMIT PROVISION DIRECTIVE	▲								▲								▲							
FORMULATE & TRANSMIT DELIVERY DIRECTIVE	▲								▲								▲							

Figure IV-4. Decision Table for Determination of Actions to Implement Nuclear Considerations

CHAPTER V
NUCLEAR EMPLOYMENT DESIGN PROCESSES IN INWARS

A. INTRODUCTION

In this chapter, the processes involved in designing a nuclear weapons employment in INWARS will be described. Naturally, the employment of nuclear weapons involves much more than specifying a package of nuclear weapons. The package itself may be regarded as an aggregation of a more detailed nuclear fire plan which provides an association between certain acquired targets, appropriate Basic Munitions Groups, and certain nuclear delivery entities. Moreover, the employment of nuclear weapons will typically entail certain changes to ongoing operations which must be developed and appraised.

B. OVERVIEW OF THE PROCESS

The procedures by which nuclear employments are designed and developed in INWARS embody a "concept-guided" process similar in approach to the operations development processes in INWARS. In particular, nuclear employment design is guided by certain user-specified nuclear employment concepts. As discussed in Section B.1 below, a nuclear employment concept provides "abstract" planning guidance concerning which types of enemy force elements should be targeted and what effects should be inflicted on them.

The abstract planning guidance contained in a concept of nuclear employment is utilized by C^2I elements in a process of specification and refinement somewhat similar to the conventional operations development sequence. Here, however, the specification and refinement sequence is more functionally oriented, focussing first on nuclear fire planning, then on estimation of results, and finally on operations development. These processes and their overall organization in nuclear employment design are surveyed in Section B.2, below. The individual processes themselves will be presented in detail in the following sections.

1. Nuclear Employment Concepts in INWARS

As was just noted, nuclear employment design in INWARS is a concept-guided process, much like conventional operations development. The user provides the model with guidance concerning the generic types of alternatives to consider; the C^2I elements then use these generic alternatives to generate specific alternatives tailored to the particulars of their situation.

a. The Structure of a Nuclear Employment Concept in INWARS

Nuclear employment concepts in INWARS specify approaches to fire planning, especially as regards the suitability and priority of various types of potential nuclear targets (i.e., force elements). Nuclear employment concepts thus reflect such notions as "counter-maneuver", "counter-support", "counter-air", and so forth. To accomplish this, each concept of employment provides an association between target types and suitability/priority indicators which specify whether or not the associated target type is suitable for nuclear targeting and, if so, its relative priority. For each suitable target type, the concept also provides an indicator of the level of effects desired against that target; (this relates back to the effect levels associated with the various Basic Munitions Groups). Finally, each concept contains guidance concerning the allocation of weapons between a C^2I element using the concept and his subordinates. This guidance specifies "where" detailed targeting is done; it may be regarded as a measure of decentralization under a particular concept.

Figure V-1 illustrates the structure of a nuclear employment concept in INWARS. Under the 'Suitability/Priority Indicator' column, the strictly positive numbers indicate suitable targets whose priority corresponds to the magnitude of the number. In the example, only two priorities appear; all priorities (up to seven) could be used in formulating concepts. Moreover, more than one target may be assigned the same priority. For example, both committed and reserve/reinforcing maneuver units could have been given a priority of 1; this would cause the targeting process to be

CONCEPT 1	SIDE	DIRECT/SUBORDINATE ALLOCATION
TARGET TYPE	SUITABILITY PRIORITY INDICATOR	EFFECT INDICATOR
C^2I ELEMENT	0	0
MANEUVER BDE/REGT (COMMITTED)	1	LEVEL 2
MANEUVER BDE/REGT (RESERVE/REINFORCING)	2	LEVEL 3
AIR BASE CLUSTER	0	0
COMBAT SERVICE SUPPORT COMPLEX	0	0
NUCLEAR CAPABLE DELIVERY ENTITY	0	0
NUCLEAR WEAPONS SUPPLY POINT CLUSTER	0	0

Figure V-1. Illustrative Nuclear Employment Concept in INWARS

indifferent between the two types of maneuver units. The 'Effect Indicator' column specifies that Level 2 effects are more desirable on committed maneuver elements, while Level 3 effects are desired on reserve/reinforcing maneuver elements. Finally, the "Direct/Subordinate Allocation" factor of 0.6 indicates that of the available weapons, approximately 60 percent should be directly targeted by the C^2I element itself; the remaining 40 percent would thus be left to the C^2I element's subordinates for targeting.

b. The Organization of Nuclear Employment Concepts in INWARS

As Figure V-1 suggests, individual nuclear employment concepts have a relatively simple structure in INWARS. However, their overall organization as generic alternatives may be somewhat complex due to the fact that certain concepts of employment can only be considered at higher echelons. A corps, for example, cannot effectively consider and develop a "counter-air" employment concept. For this reason, the individual concepts must be organized in terms of levels corresponding to the lowest echelon at which they can be considered. Figure V-2 portrays this idea for some illustrative concepts of employment.

2. The Nuclear Employment Design Process in INWARS: An Overview

The basic stages in designing a nuclear package in INWARS are portrayed in Figure V-3. For a given concept of employment, these stages are performed sequentially from left to right. However, many of the stages contain appraisals which, if failed, may force the process to go back and start over with a new concept of employment.

a. Designing a Fire Plan

The first stage in the process is the design of a nuclear fire plan. Such a plan specifies an association between targets, Basic Munitions Groups, and delivery entities. The process by which a nuclear fire plan is prepared is driven by the nuclear employment concepts discussed earlier. First, a nuclear employment concept is tentatively adopted -- i.e., the nuclear fire planning guidance associated with the concept is tentatively adopted for planning purposes. Once adopted, the concept is "developed": target suitabilities and priorities are used

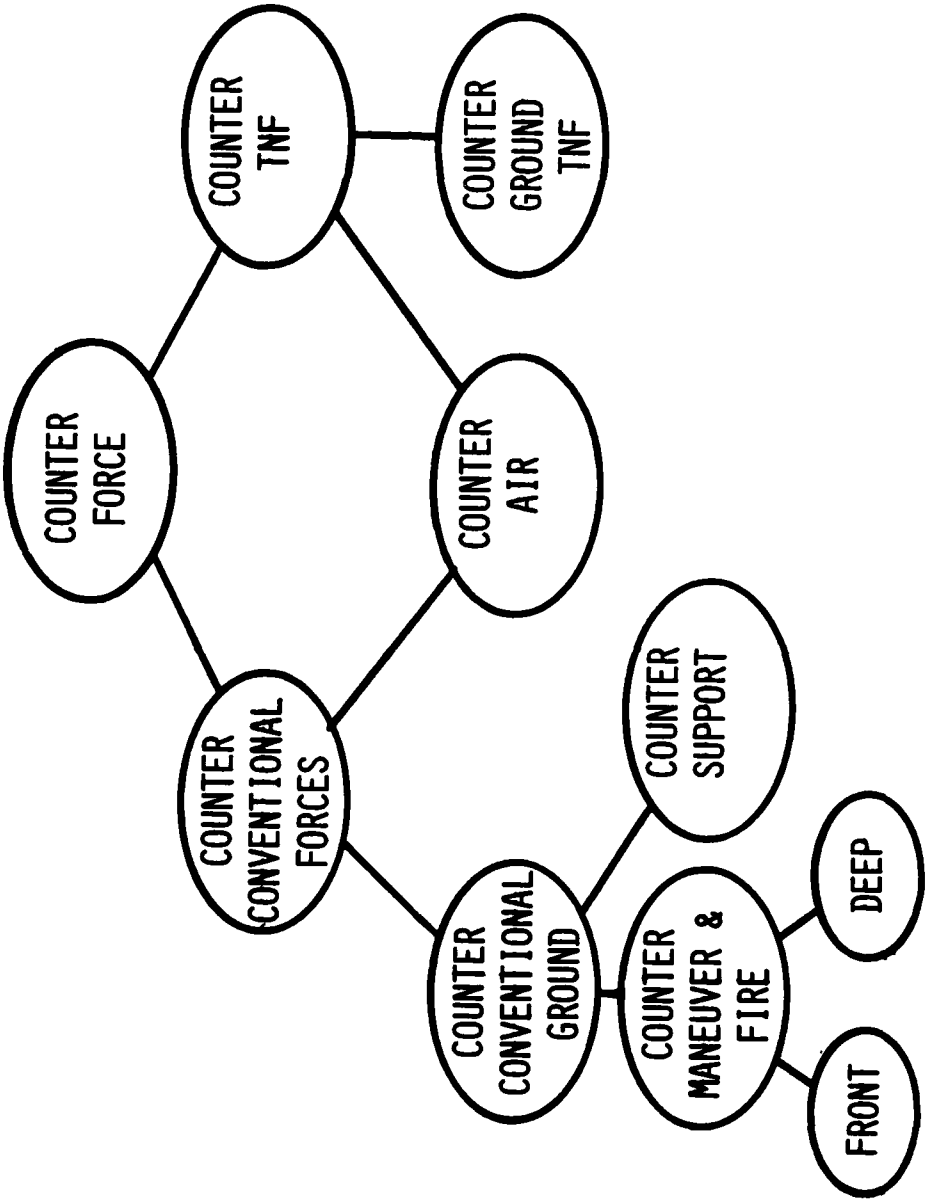


Figure V-2. Illustrative Hierarchy of Nuclear Employment Concepts

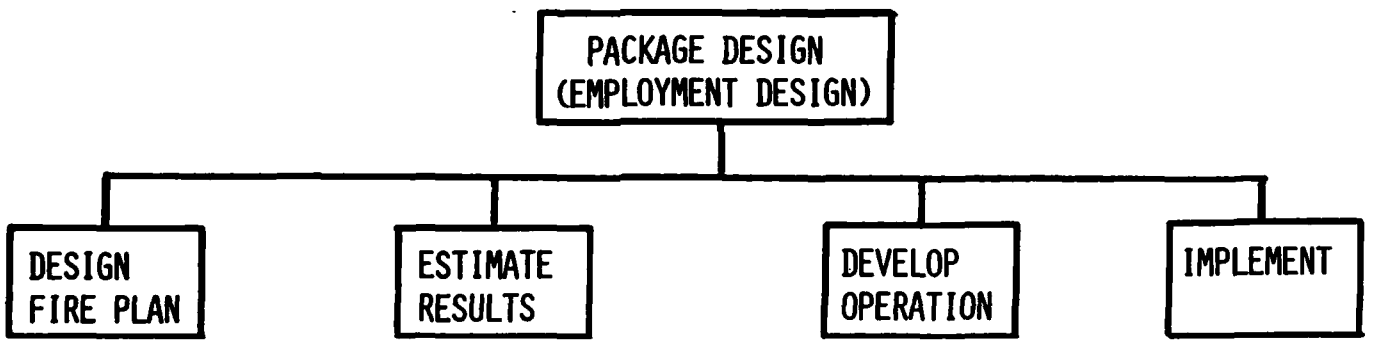


Figure V-3. Structure of Nuclear Employment Design in INWARS

together with various military and political constraints to develop an association between targets, Basic Munitions Groups, and delivery entities. This most basic stage of employment design is presented in detail in Section C, below.

b. Estimating the Results of a Nuclear Fire Plan

Once a nuclear fire plan has been developed, its results must be estimated and appraised. These "results" include the expected effects on the enemy forces and the expected response of the enemy. Effects are estimated in terms of force balance; they are appraised in terms of whether the change in force balance is sufficiently large to have a "significant" impact on the situation. Enemy response is estimated in terms of generic magnitude ("no response" versus "response in kind" versus "escalation"); it is appraised in terms of political and military constraints on "acceptable" response levels. These estimates and appraisals are discussed in more detail in Section D.

c. Developing an Operation to Capitalize on the Employment

If the nuclear fire plan successfully passes the appraisals of its expected results, it will have an "acceptable" level of overall impact on the enemy forces' ability to pursue their campaign. In order to exploit this impact, friendly forces may find it desirable to change their operations in some ways. The next stage in the design process provides an opportunity for the C^2I element to consider changes to its operations. This is accomplished by going through the standard operations development sequence using the estimated situation data (i.e., current situation less estimated effects of the fire plan). This stage is discussed briefly in Section E.

d. Implementing the Design Decision

To implement the nuclear employment designed in the preceding stages, a C^2I element must formulate and transmit a set of messages appropriate to the nuclear planning context, its employment decision, its employment authority, and its nuclear capability. This last stage of the design process was discussed in Chapter IV, Section C, above.

C. DESIGNING A NUCLEAR FIRE PLAN IN INWARS

Nuclear employment concepts play their basic role in the first stage of employment design, namely, designing a nuclear fire plan. The structure of this design process is portrayed in Figure V-4. First, a nuclear employment concept is tentatively adopted as a basis for planning. Second, nuclear weapons available for targeting are determined and allocated between direct and subordinate control in accordance with the concept's guidance. Finally, those weapons under direct control are associated with specific targets and delivery entities. These three steps are discussed respectively in Sections C.1, C.2, and C.3, below.

1. Adopting a Nuclear Employment Concept

The particular employment concepts which may be considered for adoption in any instance of the employment design process are determined by: (1) the echelon at which the design process is being carried out, and (2) the nature of the stimulus to consider employment (direct stimulus versus request from subordinate versus authorization from superior). As was noted earlier, certain types of employment concepts can only be considered at higher echelons of command. A particular C^2I element is thus always limited to considering concepts suitable for his echelon. Moreover, if the considerations were the result of a direct stimulus (problem or opportunity) the C^2I element may consider and adopt any such nuclear employment concepts. However, if the considerations were the result of a derived stimulus (request from subordinate or authorization from superior), additional restrictions may be imposed as discussed below.

2. Allocating Weapons for Targeting

Before the adopted concept's target priority and effects indicators can be used in actual targeting, the weapons available for targeting must be determined. This involves two separate considerations: (1) the total amount of weapons available to the command, and (2) the portion of those weapons which should be directly targeted by the C^2I element itself versus the portions which should be individually targeted under the control of subordinate C^2I elements. Figure V-5 illustrates the structure of these determinations.

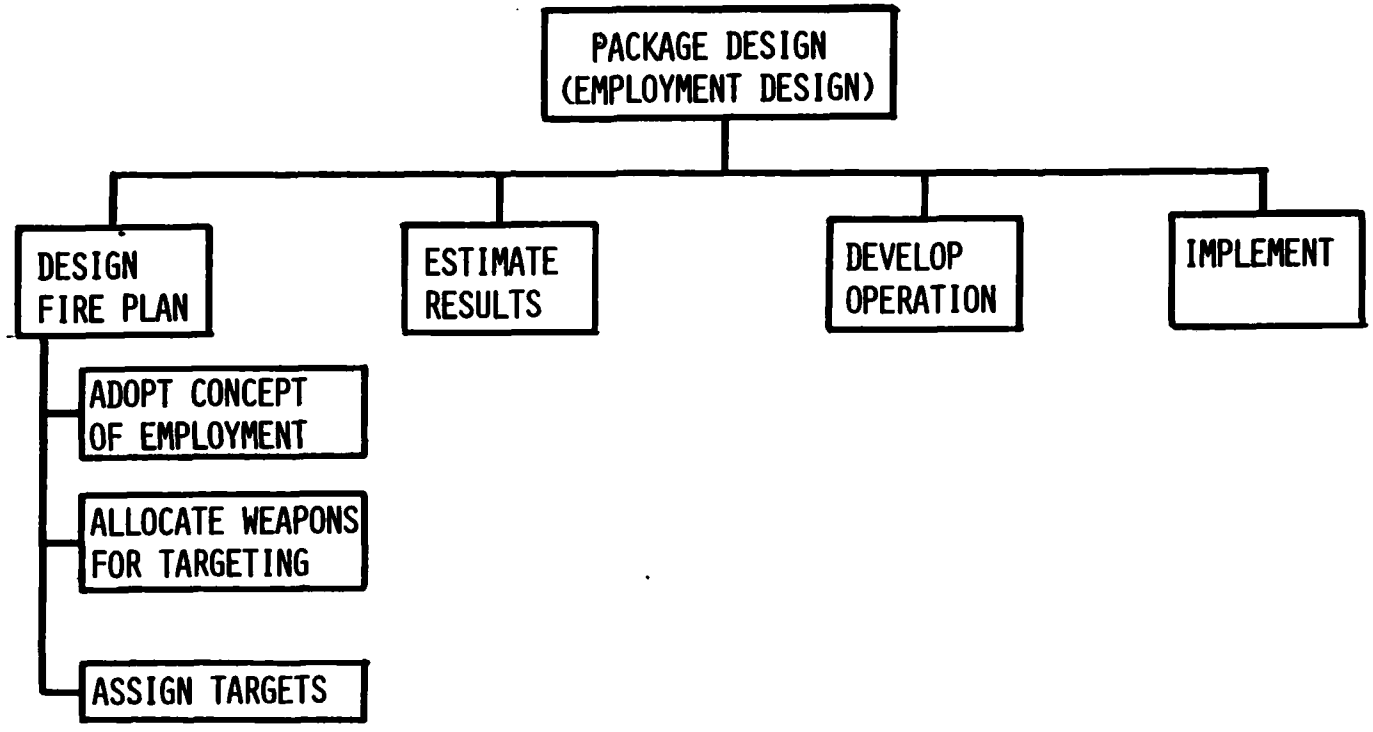


Figure V-4. Nuclear Fire Plan Design Process in INWARS

DETERMINE TOTAL MUNITIONS AVAILABLE FOR USE

ALLOCATE BETWEEN SELF AND SUBORDINATES

ALLOCATE SUBORDINATE USE AMONG SUBORDINATES

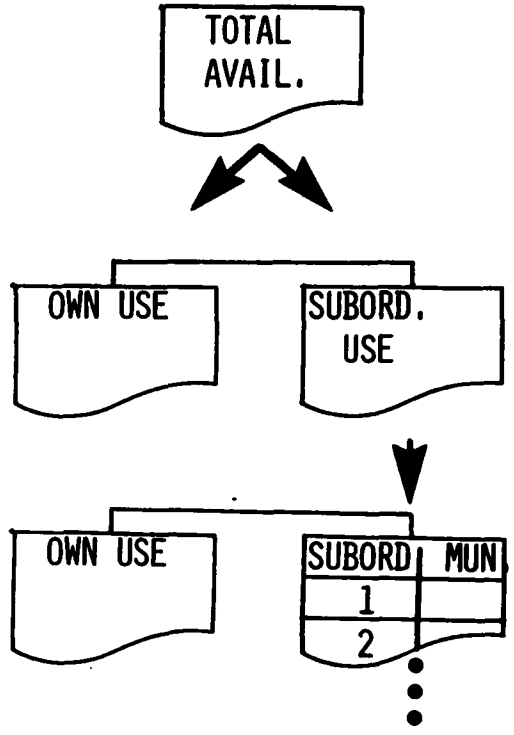


Figure V-5. Allocation of Weapons for Targeting in INWARS

a. Determining the Munitions Available

The first step, determining the munitions available, is contingent on the type of stimulus. If this particular instance was initiated by the receipt of an employment authorization from the superior C^2I element, then the nuclear munitions available for use are specified in the authorization itself. In all other cases, the munitions available for use are taken to be those allocated (for planning purposes) in the current operations order.

b. Allocating the Available Munitions Between Direct Control and Subordinate Control

This step determines the extent to which detailed targeting will be done by the C^2I element itself versus its subordinate C^2I elements. As will be seen below, the result here is an upper bound on direct control munitions -- if few targets have been acquired, the C^2I element may not be able to utilize all of its direct control munitions. Thus, this allocation reflects policies regarding "where" nuclear targeting should be performed in the overall command hierarchy. Since this may vary between sides and further, among the different employment concepts of a side, guidance on this allocation is included directly as a part of the employment concept itself. This is accomplished by a Direct Control Allocation Factor which reflects the fraction of available munitions which should be allocated for direct control by the C^2I element. Thus, the allocations are made by simply scaling the available munitions by the appropriate factors:

$$DCM = DCAF * AVMUN \quad (V\text{-}1)$$

$$SCM = (1\text{-}DCAF) * AVMUN \quad (V\text{-}2)$$

where:

DCM	=	Direct Control Munitions
SCM	=	Subordinate Control Munitions
DCAF	=	Direct Control Allocation Factor (extracted from the employment concept under development)
AVMUN	=	Available munitions as determined in the first step of detailing.

c. Allocating Subordinate Control Munitions Among Subordinates

Although detailed targeting of subordinate controlled munitions is left to subordinates, the C^2I element must still determine how to allocate these munitions among the individual subordinates. In INWARS, this allocation will be made on the basis of force balance. That is, each subordinate will be allocated a relative share of the subordinate control munitions which is inversely proportional to his relative force balance:

$$SCM(I) = SCM^* \left[\frac{\left(\frac{1}{FB(I)}\right)}{\sum_I \left(\frac{1}{FB(I)}\right)} \right] \qquad (V\text{-}3)$$

where:

SCM = Subordinate Control Munitions (as determined in Equation V-2)

SCM(I) = Subordinate Control Munitions Allocated to Subordinate I

FB(I) = Current Force Balance of Subordinate I

In essence, this approach uses inverse force balance as an index of "need" for nuclear munitions.

3. Targeting

The last step in the design of a fire plan in INWARS is the actual targeting process: developing associations between specific targets, nuclear weapons (in the form of Basic Munitions Groups), and delivery entities. These associations are developed in the form of a nuclear target plan as shown in Figure V-6. The development is guided by the target suitability/priority indicators and the corresponding desired effects indicators of the adopted nuclear employment concept. Additionally, certain political and military constraints may limit or modify the target-weapon associations. Of course, only acquired targets can be considered in making these associations, and an association can be made only if weapons and appropriate delivery entities are available. Thus, it is in the targeting process that the employment concept is "fitted" to the specific situation.

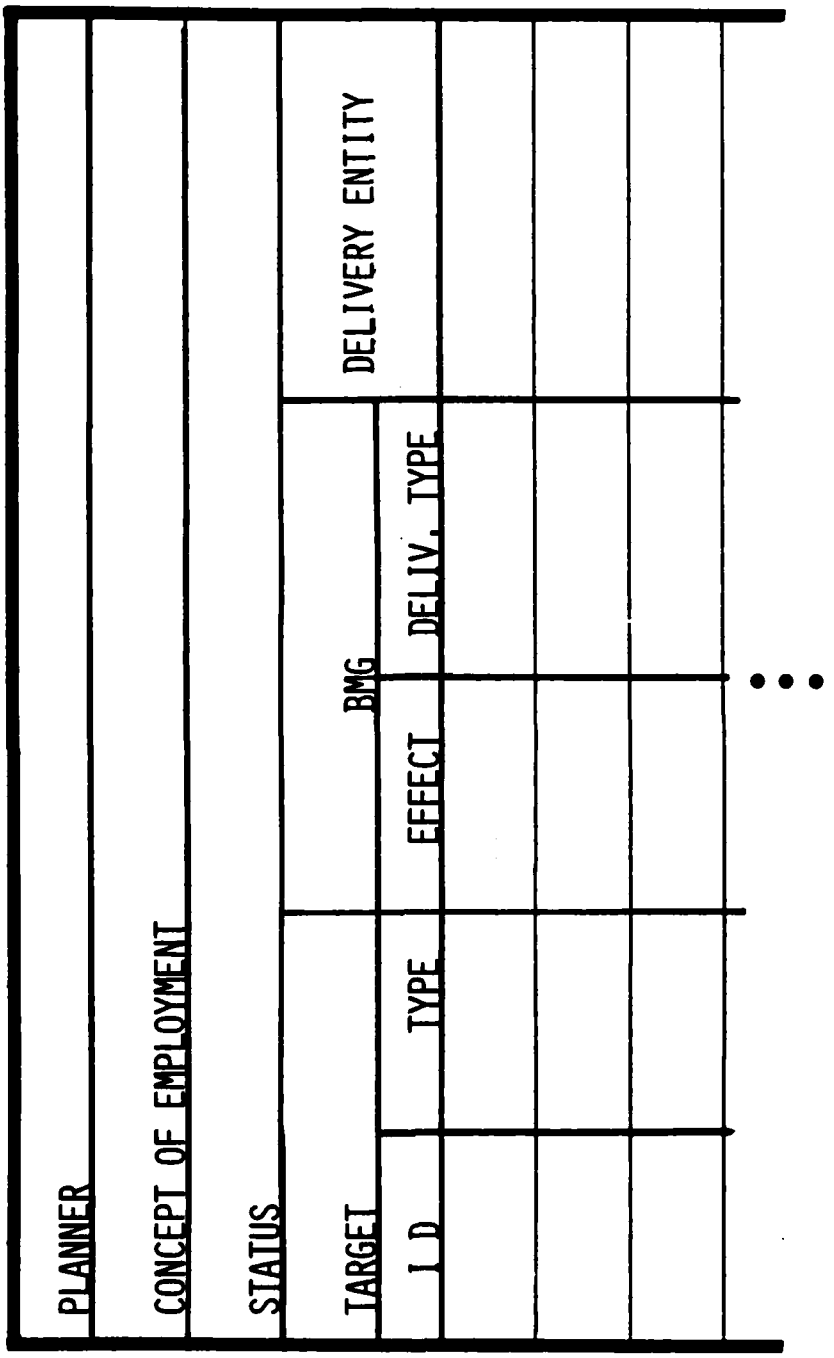


Figure V-6. Structure of a Nuclear Target Plan in INWARS

The conceptual structure of the nuclear targeting process in INWARS is portrayed in Figure V-7. Note that the overall process is partitioned into two stages. The first stage produces an ordered list of targets which are: (1) currently acquired by the C^2I element, and (2) suitable for nuclear targeting under the adopted employment concept. The ordering of the list reflects the relative priorities of the targets under the adopted concept. Thus, this list contains all and only those targets which should be considered in the targeting process: it will accordingly be termed the potential target list. The second stage is an iterative application of a basic target assignment process. As can be seen, this assignment process involves: (1) making a tentative assignment of delivery entity and Basic Munition Group to the target based on the availability and capability of delivery entities, and on the desired effects indicator in the adopted concept, (2) adjusting this tentative assignment for safety constraints, national territory constraints, and/or collateral damage constraints, and (3) updating the target plan accordingly. This process is applied iteratively to targets in the potential target list starting, of course, with the highest priority targets. The iteration continues until either: (1) all targets on the list have been considered, or (2) all munitions allocated to direct control have been assigned.

In general, this targeting process is applied only to the weapons allocated to direct control. However, at the Corps/Army level, INWARS C^2I elements will also target weapons assigned to subordinate control. Divisions will not, in INWARS, be capable of nuclear fire planning. Hence, parent Corps/Armies must necessarily do this targeting. The procedure is exactly as outlined above; it is applied to each subordinate division individually.

a. Preparing the Potential Target List

The only source of targets for consideration by a C^2I element is its Understanding of the Situation (UOS). Specifically, as a part of the Situation Data Component of its UOS, each C^2I element maintains certain target engagement information. This is organized as a list of Target Engagement Information (TE) blocks on a target-by-target basis.

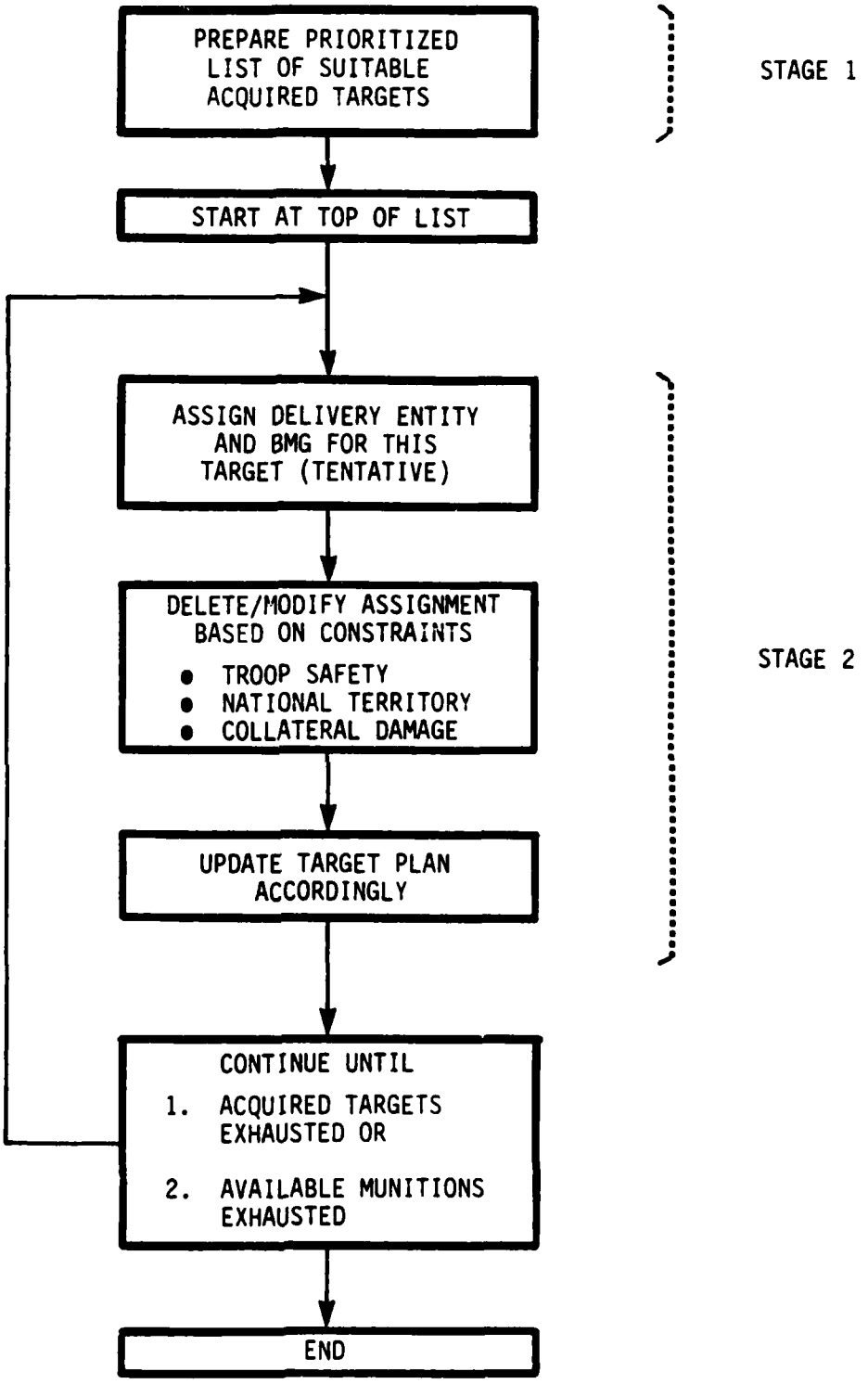


Figure V-7. Conceptual Structure of Nuclear Targeting Process in INWARS

Each such block contains various information about a specifically identified target including the time at which it was last observed. Additional information about the target (location, strength, etc.) may be found by cross reference to corresponding Enemy Order of Battle Information Blocks, also maintained in the Situation Data Component of the C^2I element's UOS.

The potential target list may be regarded as a filtered and reorganized version of the list of Target Engagement Information Blocks in the C^2I element's UOS. Specifically, the potential target list is prepared by testing each TE block for:

- Current Acquisition: The mere presence of a TE block does not insure that its target is currently acquired since the information may have aged; thus, the last observation time must be within a certain threshold of the current time.
- Suitability for Nuclear Targeting: Only certain types of targets may be suitable for nuclear targeting under the adopted employment concept; thus, the target type must have a strictly positive suitability/priority indicator under the adopted concept.

All TE blocks passing both of these tests yield potential targets (under the adopted concept). The total potential target list is then produced by simply sorting these potential targets in order of their priority under the adopted employment concept.

b. Assigning a Delivery Entity and BMG to the Potential Target

As each potential target on the resulting list is considered, an initial, tentative assignment of a delivery entity and an appropriate Basic Munition Group (BMG) must be made. This provides a starting point which may require modification based on analysis of various constraints as will be discussed later. This tentative assignment process focusses first on the selection of an appropriate delivery entity, and then on the selection of an appropriate BMG.

1) Delivery Entity Selection

It will be recalled that there are three generic types of nuclear delivery entities in INWARS: (1) artillery, (2) surface-to-surface missile, and (3) air. It will be assumed that there is a fixed

order in which delivery entity types are considered for utilization. Thus, starting with the most preferred delivery entity type, a C^2I element determines whether any of that type is available for his utilization, either as an organic resource (e.g., artillery), or as an allocated capability (e.g., air). If some is available as an allocated capability, that delivery entity is selected, thus completing the selection process. If, on the other hand, some is available as an organic resource, a particular subordinate delivery entity must then be found which is within range of the target under consideration. If such an entity can be found, it is selected. Otherwise, the next type of delivery entity in order of consideration is analyzed in a similar fashion. This process continues until either: (1) an appropriate entity is selected, or (2) all three delivery entity types have been considered without success. In the latter case, the target under consideration is removed from the potential target list as an "infeasible target".

2) Basic Munition Group (BMG) Selection

Presuming an appropriate delivery entity has been found and selected, the initial, tentative selection of a BMG is quite simple. At this point, the C^2I element has: (1) the type of the target under consideration (C^2I element, committed maneuver brigade/regiment, etc.), (2) the type of the delivery entity just selected (artillery, missile, or air), and (3) the desired level of effects for that target type under the adopted employment concept. But these three elements of information uniquely define a specific Basic Munitions Group. This unique BMG is selected, thus establishing a complete association between a specific target, a specific delivery entity, and a specific BMG.

c. Adjusting the Association to Satisfy Constraint

The target-delivery entity-BMG association just developed is tentative because political or military constraints may require that it be modified or even deleted from the target plan. Direct constraints on targeting considered in INWARS include: (1) troop safety, (2) national territory, and (3) collateral damage. Their potential impacts are discussed in the following paragraphs.

1) Troop Safety Constraints

There is a single troop safety constraint in INWARS: nuclear weapons may not be utilized in a hex perceived to be occupied by a friendly force element. If such a situation exists, the target under consideration is simply deleted from the target plan. Of course, since this constraint is assessed on the basis of perceived locations, C^2I elements may: (1) erroneously plan to employ in a hex actually occupied by a friendly force element, or (2) erroneously exclude a target in a hex not actually occupied by a friendly force element.

2) National Territory Constraint

In the INWARS hexagonal representation of geography, each hexagon at the lowest level (9.45 km diameter hexes) has a nationality attribute. The user may input political constraints on the extent to which nuclear weapons may be employed in various national territories on a hex-by-hex basis. Thus, the size of the BMG associated with a particular target may be tested against the constraint corresponding to the national territory in which the target is perceived to be located. If the BMG is too big, a BMG at the next lower effect level is considered. If an acceptably small BMG can be found, it is used in lieu of the initially assigned BMG. Otherwise, the target is deleted from the target plan.

3) Collateral Damage Constraint

Like national territory, collateral damage is considered on a hex-by-hex basis. Another hex attribute is population density. As a part of the targeting process, collateral damage is estimated as a function of the Basic Munition Group associated with a potential target and the discrete population density category of the hex in which the target is perceived to be located. If this estimate exceeds the constraint on acceptable collateral damage levels, a smaller Basic Munitions Group will be assigned to the target or, if none exists, the target will be deleted from the target plan.

4. Summary

Through the processes described above, C^2I elements design a nuclear fire plan prescribing an allocation of weapons and a specific

target plan for those weapons allocated to direct control. It is worth emphasizing that at this point in the overall employment design, the overall fire plan is still tentative. Other tests must be passed before it will be considered for implementation; these tests are described in the sections that follow.

D. ESTIMATING AND APPRAISING THE RESULTS OF A NUCLEAR FIRE PLAN IN INWARS

Once a nuclear fire plan has been developed as described in Section C, it must be considered and appraised in terms of its expected results. These "results" include: (1) the effects on enemy force elements, and (2) the response of the enemy. In this section, procedures by which INWARS C^2I elements estimate effects and expected response will be presented. Additionally, procedures for appraising these results will be described. (See Figure V-8).

1. Estimating Effects on Enemy Forces

Expected effects on enemy forces are the most basic fire plan results to be estimated. In reality, the expected effects of a nuclear fire plan have many dimensions: (1) physical effects (personnel attrition, materiel destruction, communications degradation, and terrain impacts); (2) organizational effects (radical changes in organizational capabilities and chain-of-command); and (3) mental effects (morale and stress factors). In INWARS, however, expected effects must be estimated in far fewer dimensions to conserve space and run time. Consistent with this requirement (and with the treatment of conventional C^2I processes), INWARS C^2I elements will estimate the effects of a nuclear fire plan in terms of a single measure: force balance (or more properly, effective force balance). As described in the paragraphs below, this involves estimating the effects of individual Basic Munition Groups (BMG) against their assigned targets, and then aggregating the resulting enemy forces to develop force balance estimates. As a part of the aggregation process, maneuver force strengths are adjusted for the impact on non-maneuver targets (i.e., C^2I elements, combat service support complexes, and air base clusters).

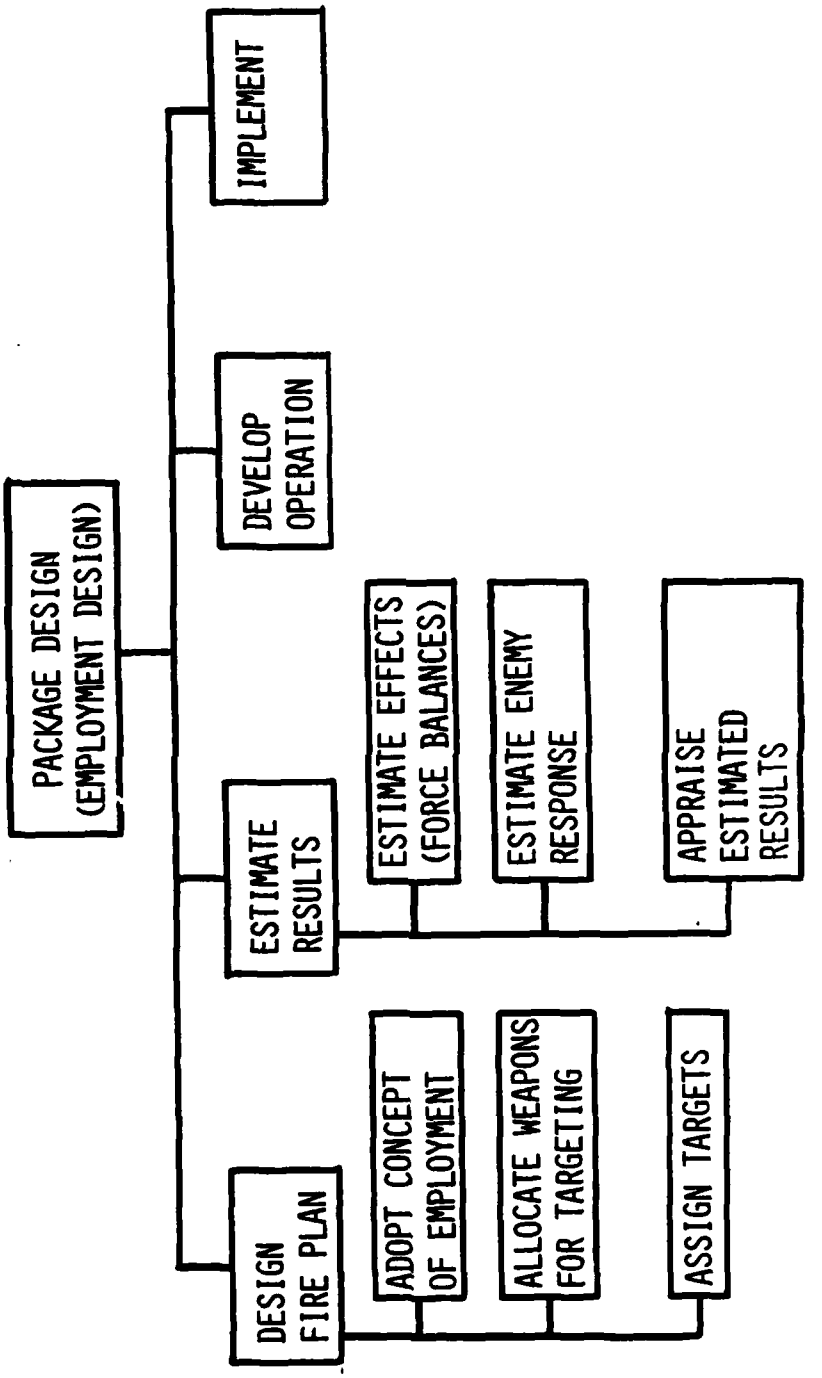


Figure V-8. Estimating and Appraising the Expected Results of a Nuclear Fire Plan

a. Estimating the Effects of Individual BMG's on their Assigned Targets

At the individual BMG-target level, effects are estimated on the basis of the BMG effects level and the perceived strength/capabilities of the target. BMG effects levels may be characterized in terms of fractional reduction of a "full-strength"/"full capability" target. Thus, the BMG's effect level must be adjusted for the strength/capability level at the time of targeting before it can be used to estimate effects on individual targets. In INWARS, this will be accomplished by simply scaling the BMG's effect level to the relative strength level of the unit. Equation V-4 reflects this adjustment process.

$$FRCEFF(BMG,UNIT) = EFFLEV(BMG)* \left(\frac{STRENGTH\ (UNIT)}{FULL\ STR\ (UNIT)}\right) \qquad (V-4)$$

where:

FRCEFF(BMG,UNIT)	=	Fractional effect of the given BMG against the given target unit
EFFLEV(BMG)	=	Fractional effect level of the BMG (against A full strength unit)
STRENGTH(UNIT)	=	Perceived strength of the target unit
FULLSTR(UNIT)	=	Full strength of the target unit.

Effects are then estimated by applying the adjusted fractional effect against the perceived strength of the unit:

$$ESTEFF(BMG,UNIT) = FRCEFF\ (BMG,UNIT)*STRENGTH(UNIT) \qquad (V-5)$$

where:

ESTEFF(BMG,UNIT)	=	Estimated effect of the given BMG against the given target unit.

Of course, the preceding procedure applies only to direct control munitons, i.e., those assigned to a specific target. Those munitions allocated to subordinate control are not associated with specific targets; hence their effects must be estimated by assuming assignment to certain types of targets. To conserve time, this will be done on a highly aggregated basis by simply determining the enemy maneuver strength opposing the subordinate, assuming a certain portion of this to be acquired and accessible, and then estimating the effect in terms of reductions to this acquired and accessible strength.

b. Aggregating Gross Maneuver Effects

Once the effects of individual BMG's against their assigned targets have been estimated, maneuver unit effects must be aggregated. This involves determining the enemy maneuver units perceived to be associated with each subordinate, and then simply accumulating estimated strengths (perceived strength less any estimated effects) on a subordinate-by-subordinate basis. The subordinate unit estimates are then aggregated to an overall estimate for the C^2I element. This process produces an estimate of the gross maneuver situation resulting from the fire plan under consideration.

c. Adjusting for Non-Maneuver Target Effects

The gross maneuver estimates do not reflect the impact of non-maneuver targeting. However, if total effects are to be estimated in force balance terms, then any non-maneuver target effects must be incorporated into the gross maneuver effect. To accomplish this, INWARS C^2I elements will employ a very simple estimating model which assumes: (1) that maneuver elements require C^2I support, combat service support, and air support; and (2) that as these various support capabilities are reduced, so too is the maneuver strength which can be effectively applied on the battlefield. In other words, the absence of support constrains effective maneuver strength.

Under this simple model, gross maneuver effects are adjusted for effects on targeted C^2I elements, Combat Service Support Complexes, and Air Base Clusters. For each such unit targeted, a constraint effect in terms of maximum fractional effective maneuver strength is determined as a linear function of the estimated support capability of the unit. The associated aggregate maneuver strength is then assessed against this constraint and reduced to the constraint level if required.

It will have been noted that this adjustment process does not incorporate effects on TNF target units such as surface-to-surface missiles units or Nuclear Supply Point Clusters. Such TNF target effects will not be incorporated into the force balance effects estimates, but will rather be considered in estimating enemy response as discussed below.

d. Estimating Resulting Force Balances

Once the gross maneuver effects estimates have been adjusted for effects on non-maneuver targets, force balances can easily be developed on a subordinate-by-subordinate basis as well as on an overall basis. These force balance estimates are retained during the planning process for later estimation and decision processes. Their immediate use lies in the estimation of the enemy response.

2. Estimating Enemy Response

In INWARS, enemy response will be estimated in terms of three generic response levels:

- No Response: no nuclear response
- Response in Kind: nuclear response at a level smaller than the fire plan level plus some tolerance level:

$$RE \leq (1 + \alpha)^* FP$$

- Escalation: nuclear response a level in excess of the fire plan level plus the tolerance level:

$$RE > (1 + \alpha)^* FP$$

Note that this approach essentially defines escalation directly in terms of amount of munitions used relative to the amount used previously. This is obviously an extreme simplification of a very complex concept. However, it is felt to be a reasonable starting point which provides for future growth.

The actual enemy response to a nuclear fire plan has two basic determinants: (1) enemy intent to respond at various levels (as a function of enemy situation and policies), and (2) enemy capability to respond at various levels (as a function of munitions available and delivery capability). Thus, to estimate enemy response, INWARS C^2I elements will estimate both enemy intent and capability, and then synthesize the two into an expected response.

a. Estimating Enemy Intent

In INWARS, enemy intent to respond is determined principally by the tactical situation: enemy doctrines and policies are presumed to associate certain levels of response with various types of situations. For estimating purposes, C^2I elements characterize their enemy's situation in

terms of the force balances expected to result from the fire plan. In particular, two force balance thresholds will serve to partition the overall range of possible force balances into three expected enemy intent regions (corresponding, of course, to "no response", "response in kind", and "escalation"). This partitioning is shown in Figure V-9.

b. Estimating Enemy Capability

In INWARS, enemy capability to respond is estimated in terms of the availability of munitions. This estimate is prepared by aggregating munitions across all perceived enemy TNF elements. Of course, this aggregate must be adjusted for effects on any such TNF units targeted in the fire plan under consideration.

c. Synthesizing Intent and Capability into Response

Enemy intent and capability to respond are synthesized into an estimated response by presuming the enemy will carry out his intent to the extent capable. Thus, capability constrains intent: if the estimated intent is "escalate" but the estimated capability is too small, the estimated response would be "respond in kind" or "no response".

3. Appraising Results

As treated so far, the results of a nuclear fire plan have been estimated in terms of expected effects on enemy force balance and expected enemy response. These two estimates may now be appraised, as discussed in Paragraphs 3.a and 3.b, respectively.

a. Appraising Expected Effects

The basic criterion in appraising the estimated effects on force balance is magnitude: Is the effect on force balance sufficiently large to cause a significant change in the situation? The criterion is assessed by comparing the relative increase in friendly force balance against a threshold which defines "sufficiently large". This appraisal is included for two reasons. First, it may be used to limit the use of nuclear weapons to those situations where they can cause a substantive or even dramatic change in the situation. Second, it may be used to filter out those fire plans which offer little potential for contributing in significant ways to friendly objectives.

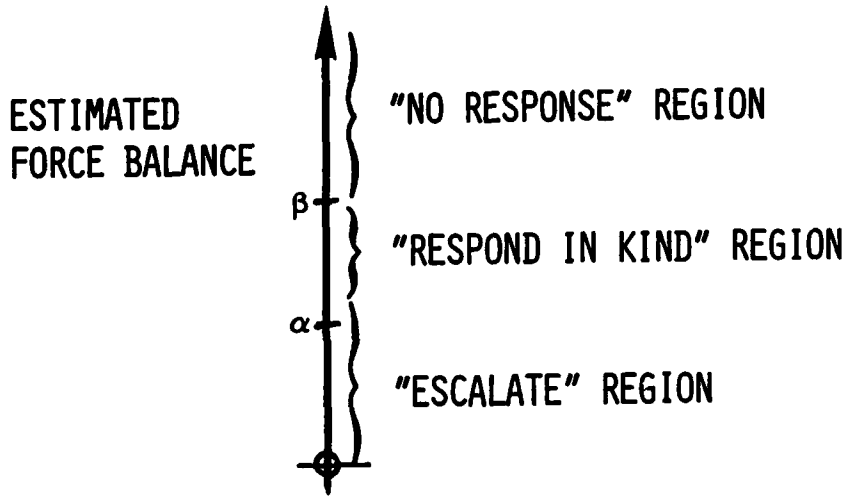


Figure V-9. Estimating Enemy Intent

If the fire plan under consideration fails this appraisal -- if it produces "too small" a change in force balance -- it is discarded. There is no way to increase the extent of the effects under the associated concept of employment: the highest priority force elements have been targeted and either all available munitions have been assigned or all acquired force elements have been targeted. Thus, if any suitable nuclear employment concepts remain untried, they will be adopted thus reinitiating the fire planning process.

b. Appraising Expected Enemy Response

The appraisal of expected enemy response considers the "acceptability" of the expected response relative to user-specified political or military constraints. These constraints define what constitutes an "acceptable response". They may take three basic forms: (1) "provocation" constraints which preclude any nuclear employment for which the expected enemy response is non-null, (i.e., for which the enemy is expected to respond in kind or escalate); (2) "escalation" constraints which preclude any nuclear employment for which the enemy is expected to escalate; and, (3) "parity" constraints which preclude any nuclear employment in which the magnitude of the expected enemy response cannot be "matched" by a friendly counter-response.

If the target plan under consideration fails this appraisal, it is, in effect, "too big". In principle, the fire plan could be reduced by sequentially deleting targets (in order of lowest priority first) and then reappraising effects until an acceptable response level was reached. However, this is potentially an extremely expensive approach in terms of computer run-time. For this reason, INWARS C^2I elements will make only one attempt to "scale down" a target plan having an unacceptable expected enemy response: all targets having a priority other than "top priority" will be deleted and the resulting fire plan reassessed. That is, the results of this new, reduced fire plan will be estimated and appraised as discussed above. Note that this reduced package may now be "too small", and thus fail to pass the effects appraisal. If, however, that appraisal is passed, the expected response appraisal may still be failed. In such a case, the fire plan is discarded without any further attempt at modification.

While this approach permits nuclear opportunities to be "passed by", it does allow some modification to fire plans without the potential for excessive run time. Moreover, it can be postulated that the top-priority targets under a concept of employment form the "core" of any fire planning under that concept and hence would not be deleted anyway (rather, a new concept would be tried). In addition, it can be postulated that if an acceptably high level of effects cannot be achieved with this top-priority "core", another concept is indicated. Thus the modification approach is not completely arbitrary.

E. DEVELOPING AN OPERATION TO CAPITALIZE ON THE EFFECTS OF THE FIRE PLAN

The direct impact of a fire plan is the reduction in the enemy forces' ability to pursue their campaign. This is important, but only to the extent that it increases the ability of friendly forces to achieve their objectives. Thus, the contribution of a particular fire plan must be assessed in terms of increased ability to achieve objectives. But this "contribution" is not only dependent on the fire plan and its direct effects, but also on what the friendly forces do to capitalize on these effects. In other words, contribution of a fire plan cannot be assessed independently of the operations of the friendly forces following the execution of that fire plan.

In order to capitalize on the effects of the fire plan, a C^2I element may find it desirable to undertake an operation different than that currently being executed. For this reason, assessing the contribution of a fire plan must be preceded by a redevelopment of operations.

As Figure V-10 suggests, this redevelopment follows the same basic procedures as the general operations development. Thus, various concepts of operation are adopted, developed, and detailed until an acceptable operation is found (or until the last suitable concept is reached). In applying these procedures to tentatively develop an operation to capitalize on an employment of nuclear weapons, the basic difference is that the various assignments, allocations, and assessments are made on the basis of

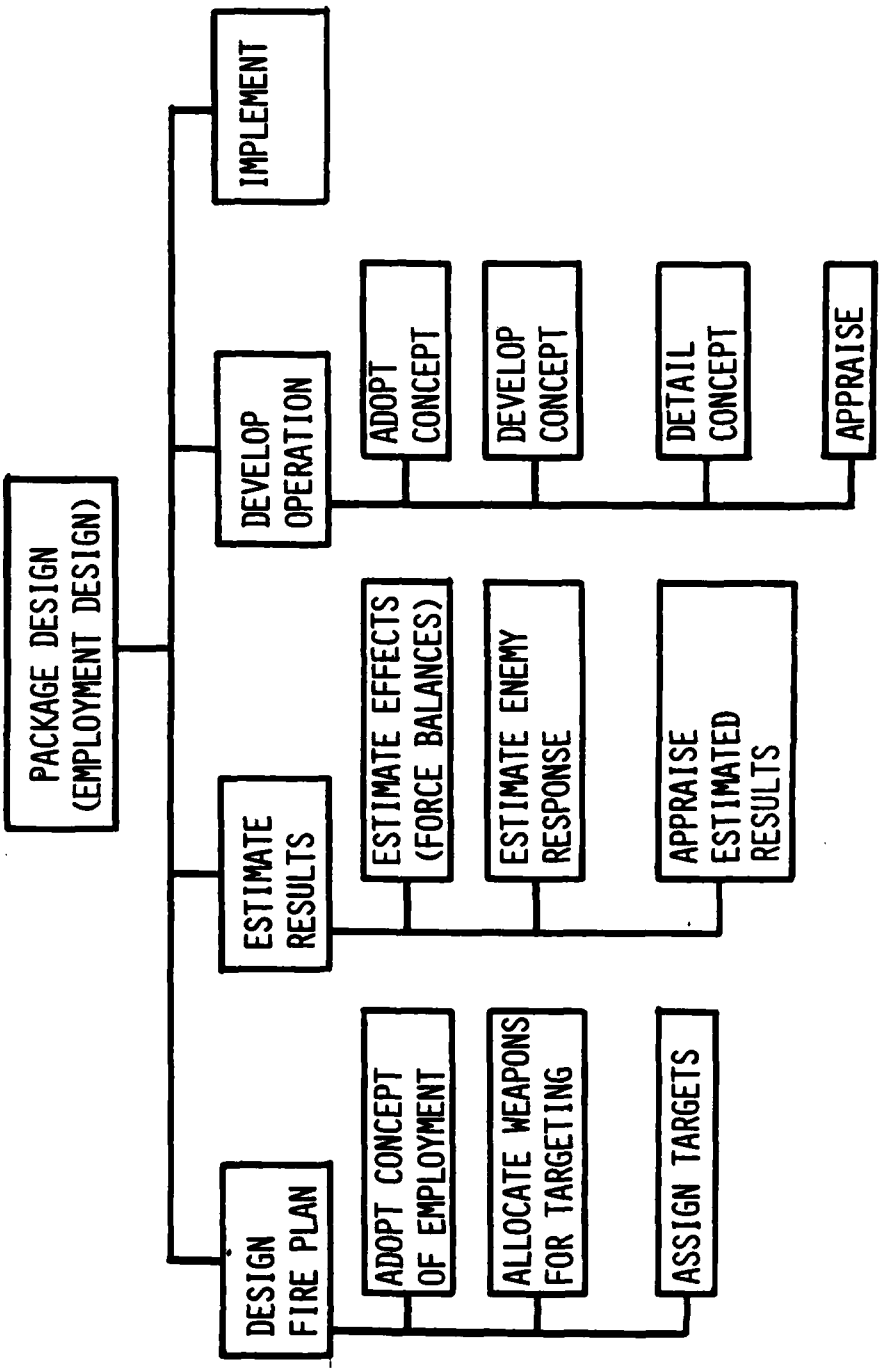


Figure V-10. Developing an Operation to Capitalize on a Nuclear Employment in INWARS

the expected situation following the employment. Moreover, at the termination of the process, the developed operation is not generally implemented, but is rather recorded for later implementation, should the nuclear employment be authorized (Of course, if the consideration of employment was stimulated by receipt of an authorization from a superior C^2I element, the implementation of the operation will be carried out).

F. IMPLEMENTING THE EMPLOYMENT DESIGN DECISIONS

The final stage in the nuclear employment design process is implementing the decisions made in employment design process. Implementing actions available to a C^2I element are limited to the formulation and transmission of various types messages. As Figure V-11 suggests, implementation consists of: (1) determining which type (or types) of messages are required, and (2) formulating and transmitting those messages. These actions were presented in some detail in Chapter IV, Section C and will not be discussed further here.

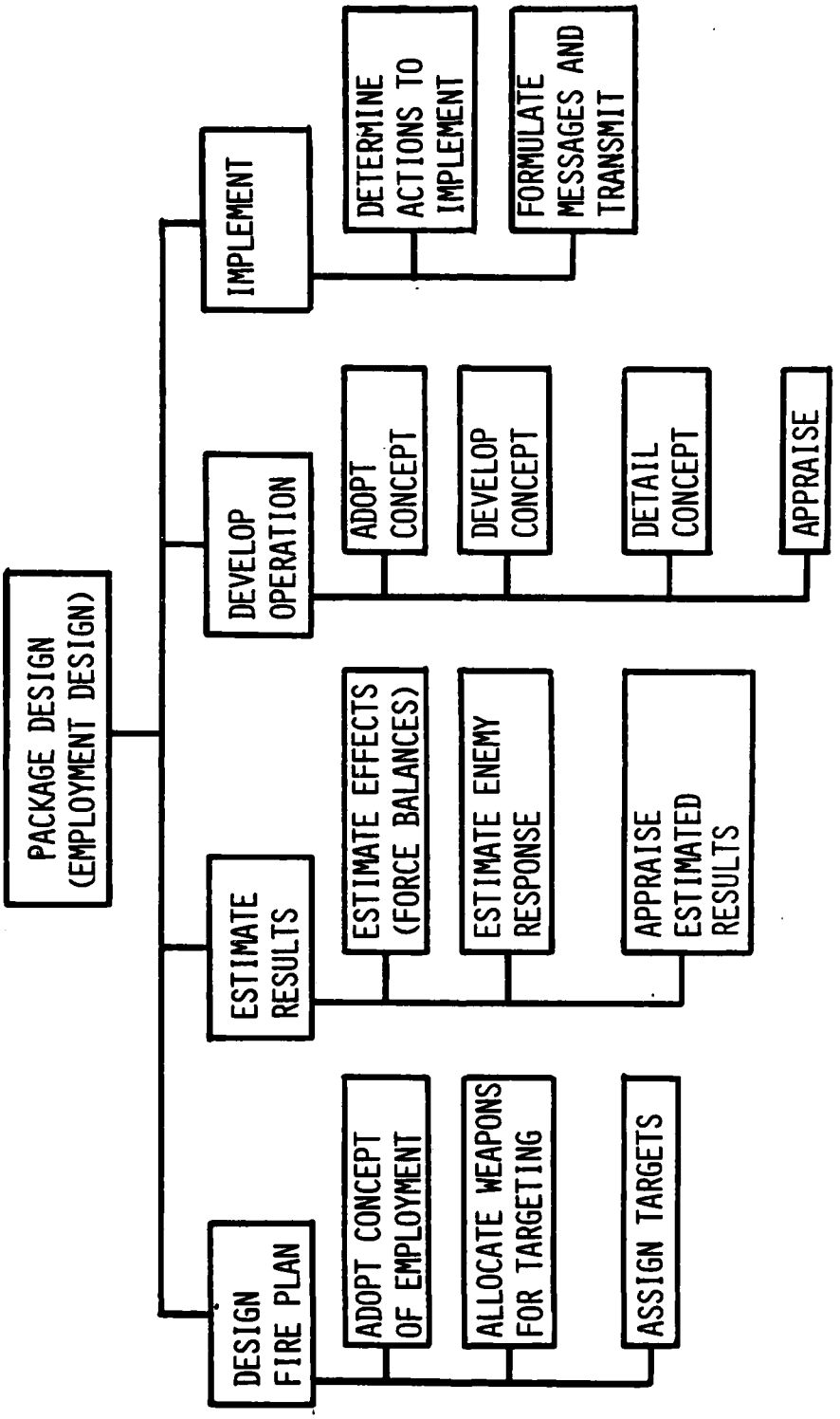


Figure V-11. Implementing the Design Decisions in INWARS

CHAPTER VI
EXECUTION OF A NUCLEAR EMPLOYMENT AND ITS EFFECTS IN INWARS

A. INTRODUCTION

The nuclear employment design processes discussed in the previous chapters may eventually result in the authorization of a specific nuclear package. This will have been implemented by the C^2I elements in the form of various types of messages to various types of force elements. The purpose of this chapter is to discuss: (1) the principal implementing directives (provision directives and delivery directives) and the activities involved in carrying out those directives, and, (2) the results of executing the employment (i.e., nuclear effects in INWARS).

B. EXECUTING THE EMPLOYMENT

In INWARS, the actual execution of a nuclear employment is carried out by one of the three types of nuclear-capable delivery entities (artillery, missile, or air). The delivery entities are supported in this process by the nuclear supply point entities which store and provide nuclear weapons to delivery entities in accordance with directives from the corresponding C^2I element.

1. Provision of Nuclear Munitions

Although delivery entities are capable of maintaining stocks of nuclear weapons, they are the last node in the nuclear provision channels and cannot issue weapons from their stocks to other force elements. The provision of nuclear weapons in INWARS is accomplished by the nuclear supply entities. These entities may receive, stock, and provide nuclear weapons to lower level nuclear supply entities or delivery entities. Such provisioning is done only under the explicit provision directives of the parent C^2I element.

Provision directives are prepared by C^2I elements as a part of implementing an authorized nuclear employment. They specify particular quantities of nuclear weapons to be provided to subordinate nuclear supply entities or nuclear delivery entities.

Upon receipt of such a directive from its present C^2I element, a nuclear supply entity will immediately compose "bundles" of nuclear weapons. One such bundle will be prepared for each lower level nuclear supply entity or delivery entity specified in the provision directive. The weapons included in each bundle will match the specifications in the directive to the maximum extent possible. Any discrepancies will be reported to the parent C^2I element. Once composed, these nuclear weapons bundles will be issued to the corresponding entities. Following a transportation delay time, the bundles will be received by the entities and incorporated into their own stocks of nuclear weapons for subsequent provision or delivery.

2. Delivery of Nuclear Munitions

Nuclear-capable delivery entities of three basic types are treated in INWARS. These include artillery, surface-to-surface missile, and air. They are represented, respectively, by attached artillery assets, surface-to-surface missile entities, and air mission packages in INWARS. As noted earlier, such entities are capable of maintaining stocks of nuclear weapons; they are also capable of receiving nuclear weapons provided by nuclear supply entities. However, their principal function is the delivery of these weapons against enemy force elements. Delivery is only carried out under explicit delivery directives received from the parent C^2I element.

Delivery directives are prepared by C^2I elements as a part of implementing an authorized nuclear employment. They specify an association between particular Basic Munition Groups and particular targets. These associations are extracted (on a delivery-entity-by-delivery-entity basis) from the particular fire plan which the C^2I element is implementing. The delivery directive also contains timing information in the form of a start time for the delivery.

Upon receipt of a delivery directive, the delivery entity checks the specified start time. If, as should be the case, the start time has not yet arrived, the entity schedules the delivery process to begin at that time. (Certain additional actions may be required to prepare for the delivery process in the case of air entities). The delivery process itself is accomplished by composing the specified Basic Munition Groups out of the entity's own stocks of nuclear munitions, and then scheduling a "nuclear detonation" event to occur in the hex where the specified target is perceived to be located. As will be discussed in the next section, the occurrence of this detonation event causes nuclear effects to be inflicted on force elements in the specified hex (and on the hex itself).

C. EFFECTS OF NUCLEAR EMPLOYMENT

The employment of nuclear weapons is implemented in three steps. When a nuclear detonation event scheduled during delivery occurs, a temporary "nuclear effects" entity is created in the hex where the detonation occurs. This entity then inflicts effects on units in the vicinity using the combat process; it also registers effects on the terrain for contamination, barrier effects, and collateral damage. The nuclear effects entity, like other entities, is controlled by an Operation Reaction System. In this case, however, the ORS serves principally to eliminate the nuclear effects entity after its effects have been registered on all appropriate entities.

1. Creation of Nuclear Entity

When nuclear weapons employment is initiated, an event is scheduled for the weapons' detonation. This event indicates the identity of the entity which is the source of the nuclear weapons, that is, the firing unit; it also indicates a Basic Munition Group which specifies the types and numbers of nuclear weapons to be employed. A target is specified either as a hex to be targeted or a unit to be targeted. It is assumed that the scheduling of the detonation event implies that the weapons are capable of reaching the target; all range and capability considerations will have been made previously.

The nuclear detonation event causes a nuclear effects entity to be created. It is given assets from the firing entity equal in numbers and types to those described in the Basic Munitions Group. As an entity, it is then subject to the same processing as others, including the combat process, during which it inflicts nuclear effects. It is also given an operation code, which is simply 'detonation'.

2. Effects on Target Units

The Nuclear Effects Entity inflicts effects directly on the target unit(s) using the standard combat process. If a target hex was specified, all units in the target hex or its vicinity may be subjected to nuclear effects. If a unit is specified as the target, it is the only unit affected directly. This latter option probably would only be employed for very small packages used in close proximity to friendly units, although the data which controls this is set by the user.

a. Basic Effects Equation

The combat effects inflicted by the nuclear effects entity include attrition and suppression. These are assessed against all targetable assets of the targeted units. Suppression is also inflicted on the unit as a whole, reflecting degradation of coordination, communication, etc. within the unit. The operation of the combat process in inflicting damage is detailed in "INWARS Combat Interactions Software Modules". The attrition and suppression equations are of the basic form:

$$\Delta x = \alpha k y^{a} \left(\frac{x}{x+t}\right) \qquad \text{(VI-1)}$$

where:

Δx = The attrition (or suppression) inflicted on the target unit

α = A combination of various factors affecting the employment of the weapon, including operational effects, allocation among target units and types, nuclear readiness posture, etc.

k = Basic effect rate for a given weapon. This is the attrition (or suppression) expected against a normally disposed homogeneous target array for an individual weapon.

y = The number of weapons detonated.

a = Weapon exponent. This reflects the nonlinear relation between the number of weapons and damage inflicted. a should be less than one, reflecting diminishing results as weapon numbers are increased.

x = The number of target assets, after taking into account disposition of the target unit. The latter is a density consideration which reflects the variance of the density from the normal for which the value k is defined due to operation type and nuclear readiness posture.

t = Terrain or space effect. This gives a measure of the protection which terrain provides.

Of the above factors, α , x, and t are the results of the other calculations which take into account various weapon and target characteristics, which are detailed in "INWARS Combat Interactions Data Structures". The equation presented above is illustrative of the form of the calculations, and does not represent the full range of effects and controls available to the user.

b. Secondary Attrition Effects

The specification of various assets allows dependent asset types to be given. This allows the dependent asset type to be attritted along with the primary type in accordance with a specified proportion. This was designed to reflect the attrition of personnel and supplies in conjunction with hardware assets. The nuclear weapons may have characteristics which inflict a higher proportion of personnel casualties than the ratio defined for conventional conditions in the asset characteristics description. This can be reflected by the weapon inflicting results on the target unit's personnel assets directly, as well as indirectly through the dependent asset mechanism. The same method can be applied to supplies, or other assets as well.

c. Suppression Effects

In addition to attrition, weapons inflict suppression on the various target assets and units. These are calculated in a manner similar to attrition, but instead of a decrease in the number of assets, the assets are given an increase in their suppression status, which defines a percent

effectiveness. The target unit as a whole is also subject to suppression, with its suppression status increased proportionately to that of the targeted asset and its relative contribution to the unit's strength. The asset suppression and unit suppression are adjusted downward each interval in accordance with rates given in the asset's descriptor block and unit operation descriptor block respectively. Unit capability increases accordingly.

d. Mental Effects

In addition to the physical effects above, a flag is set in the target unit's situation description when it is a victim of a nuclear attack. This flag may be used by the unit's Operation Reaction System in decisionmaking. The actual operation decision impact is a function of user-defined data.

3. Non-Unit Effects

In addition to the direct effects inflicted on targeted units, nuclear weapons have other effects including communications and terrain effects, and collateral damage.

a. Communications Effects

The detonation of a nuclear weapon affects communications both directly, through EMP and blackout effects, and indirectly through the suppression state of the unit. Direct effects are modeled as a delay in the time necessary to transmit a message. These delay time factors are specified for the weapon. They are registered on the parent communication networks of all units affected.

b. Terrain Effects

When nuclear weapons are employed, various effects may be made on the terrain, including radiation and physical barrier effects from tree blowdown, etc. These are aggregated into a generic nuclear effects level, which is represented in the terrain as a value of 0 (for no nuclear effects) to 7. Each weapon descriptor gives a level of nuclear effects to be inflicted on the target hex. The nuclear effects level is incremented to the specified level if it is lower; otherwise, it remains the same. There is no provision in the model for decreasing this terrain effect,

although it can be done manually by inputting a new terrain description of the hex. The nuclear effects level influences movement speed and direction choice. There is no provision for active effects, such as the attrition of a unit occupying the hex.

c. Collateral Damage

In the terrain descriptor, there is a code for population density, which may have sixteen different values. Each code is associated with a density value in a table. Collateral damage inflicted by a weapon is calculated as follows:

$$C = ky^a p \qquad \text{(VI-2)}$$

where:

C = Collateral casualties

k = Collateral damage rate specified for a given weapon type

y = Number of weapons of given type detonated

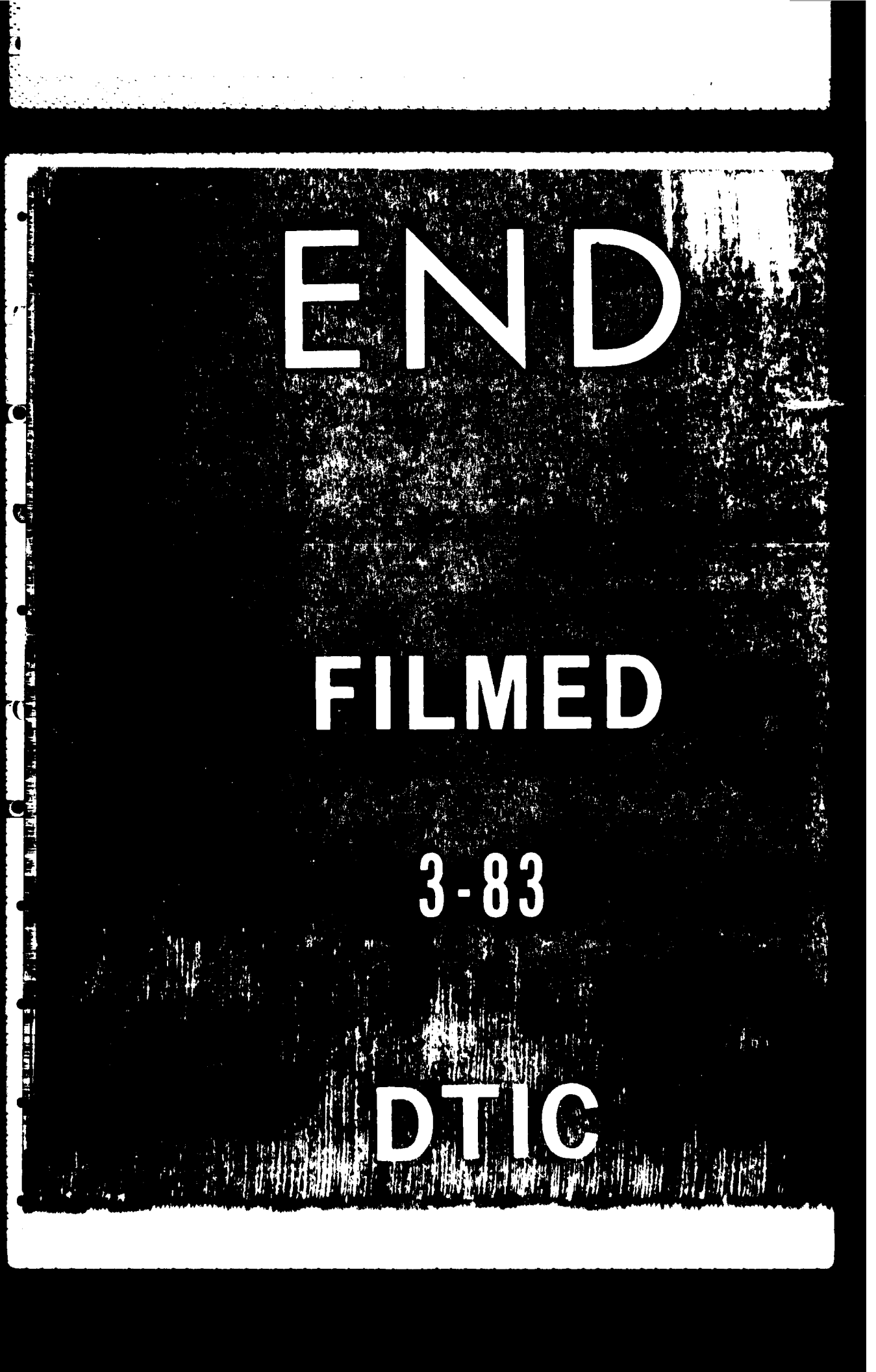
a = Exponent 1 used to reflect nonlinear effects; this is the same as the similar number used in the attrition computations

p = Population density.

The collateral damage for each nation is accumulated over the course of the simulation. Population values of the various terrain hexes will not be adjusted during the simulation to reflect evacuation, decline in density due to weapon detonations, etc.

4. Eliminating the Nuclear Effect Entity

After the nuclear effects entity has inflicted its effects, the operation of its corresponding Operation Reaction System will cause an action code which eliminates it from the simulation. In other words, all effects are registered in one combat period. Some effects (e.g., communications degradation) may persist through more combat periods; however, the nuclear effects entity itself does not, in the present treatment, have extended effects (such as, e.g., fallout).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